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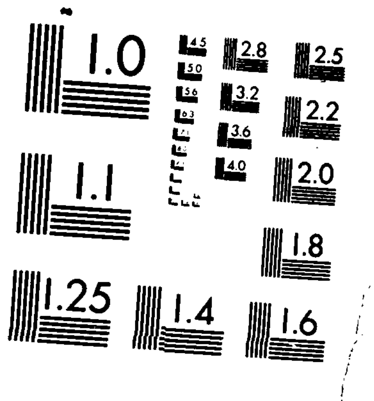

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Report No. CG-D-31-85

DEVELOPMENT OF AN ENVIRONMENTAL MONITORING PROGRAM VOLUME I

MARINE HAZARDOUS CHEMICAL WORKER
TASK II FINAL REPORT

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DEVELOPMENT OF AN ENVIRONMENTAL MONITORING PROGRAM

By

Thomas B. Morrow
J. Christopher Buckingham
Raymond J. Magott

Volume I of
Task II FINAL REPORT
Contract DTCG23-82-C-20027
SwRI Project 06-7223

Prepared for

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16. Abstract

This report describes the development of an environmental monitoring plan applied to marine industry personnel who may be potentially exposed to hazardous chemicals during their work. The goal of this plan is to minimize the worker's exposure to hazardous materials during work activities. The environmental monitoring plan includes the use of (1) safe work practices that specify how to carry out activities that involve potential exposure to hazardous materials, (2) environmental monitoring devices for measuring chemical vapor or dust concentration in the air, and (3) personal protective equipment to prevent inhalation of and skin contact with hazardous materials. The environmental monitoring plan was subjected to a trial evaluation in a series of field tests. These field tests included two job activities in which workers were potentially exposed to hazardous chemicals for (1) U. S. Coast marine inspectors and pollution prevention boarding teams, (2) merchant marine tankermen working on chemical tankerships, and (3) merchant marine tankermen working on chemical barges.

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I. INTRODUCTION

This report presents the results of the Task II - Environmental Monitoring and Instrumentation investigation performed as part of SwRI Project 06-7223, "A Study to Improve the Health and Safety of the Marine Hazardous Chemical Worker", for the U. S. Coast Guard.

I.1 Background

The term, marine hazardous chemical worker (MHCW), is used to denote an individual working in the marine industry who may be exposed to potentially hazardous chemicals in the course of performing his job. Marine hazardous chemical workers fall into four generic classes:

- o Marine chemical transport workers (tankers and barges),
- o Chemical terminal dock workers,
- o Offshore oil/gas drilling and production workers, and
- o U. S. Coast Guard field personnel.

The U. S. Coast Guard has broad responsibility for the safety and health of some MHCW personnel. This responsibility is derived in part from the Ports and Waterways Safety Act of 1978, and the Outer Continental Shelf Lands Act of 1953. A Memorandum of Understanding between the USCG and OSHA signed in March 1983 has served to clarify this responsibility in areas where the authority of these federal agencies overlap.

In order to discharge its responsibility effectively, the Coast Guard has sponsored research to identify and document the work activities performed by MHCW personnel that involve exposure to potentially harmful chemical liquids, gases and vapors. Occupational exposure studies have also been carried out during these investigations in order to characterize the duration and the level of chemical concentration to which MHCW personnel are actually exposed in their jobs. This information is needed in order to determine whether additional regulation or implementation of voluntary standards by the marine industry are required to provide for the health and safety of MHCW personnel.

The Marine Hazardous Chemical Worker (MHCW) study is a further research effort under the sponsorship and supervision of the U. S. Coast Guard. The overall objective of the MHCW study is to develop and evaluate a program designed to be implemented by the marine chemical transportation industry for the protection of the health and safety of workers who may be exposed to potentially hazardous chemicals during their work activities.

The specific objectives and the organization of effort for the MHCW study are described in Section I.2. The objectives for the Task II Environmental Monitoring Study are given in Section I.3.

I.2 Project Objectives

The MHCW study is organized in four major research tasks as follows.

- **Task I**-Background Study. The objective of this task is to perform an extensive background study in scenario form to identify and document the work activities that involve exposure to potentially hazardous chemicals for the various classes of MHCW personnel.

- **Task II** - Environmental Monitoring. The objective of this task is to develop an environmental monitoring program applicable to the MHCW scenarios identified in Task I. The monitoring plan includes the use of safe work practices, chemical concentration measuring instrumentation and personal protective equipment to minimize the worker's exposure to hazardous materials during work.

- **Task III** - Medical Monitoring. The objective of this task is to develop a medical monitoring program for MHCW personnel which will detect adverse health effects that are associated with the occupational exposure to hazardous materials. The medical monitoring plan involves gathering information through the use of work histories, measured exposure levels, medical questionnaires, physical examinations and laboratory tests, and an automated data base management system.

- **Task IV** - Trial Implementation. The objective of this task is to develop a plan for implementing the medical monitoring plan, together with the appropriate elements of the environmental monitoring plan, in the U. S. Coast Guard and in elements of the marine transportation industry that choose to cooperate.

I.3 Task II Work Activities

Task II has three main subtasks as described below.

- Subtask II.1 is an evaluation of the state-of-the-art devices for on-site environmental monitoring. Information was gathered on over 200 chemical vapor measuring instruments and detectors from more than 50 manufacturers. This information was reviewed to determine the suitability of these devices for use by MHCW personnel in the field. A representative set of instruments and detectors was also selected to undergo laboratory evaluation tests. The information that was gathered on environmental monitoring devices is presented in tabular form in Volume II of this report. The results of the laboratory evaluation tests are reported in Appendix M of Volume II.

- Subtask II.2 involved the development of an environmental monitoring plan, and adapting that plan for each of the MHCW scenarios identified and described in Task I. This involves identifying the chemical to which the worker may be exposed, and performing a sequence of measurements and evaluations to determine whether work can be performed safely, and what type of protective equipment should be used to minimize the worker's exposure. The development of the environmental monitoring plan and its adaptation to the MHCW scenarios is described in Chapters II and III of this Volume.
- Subtask II.3 involves subjecting the environmental monitoring plan to a trial run in a series of field evaluations. Two MHCW scenarios were selected for evaluation for each of the following classes; (1) USCG personnel, (2) merchant marine on vessels, (3) merchant marine on barges. The results of the trial run field tests are described in Chapter IV and in Appendices C, D, and E of this volume.

II. DEVELOPMENT OF THE ENVIRONMENTAL MONITORING PLAN

The environmental monitoring plan developed in Task II and the medical monitoring plan developed in Task III are complementary in scope. The goal of the environmental monitoring program is to minimize the exposure of MHCW personnel to hazardous chemical vapors during their work activities. The goal of the medical monitoring program is to detect and correct the symptoms of illness or disease that may be related to the occupational exposure to hazardous chemicals.

The term, environmental monitoring (as it is used in this project) means a determination of chemical concentration in an area where work is to be performed. However, the environmental monitoring plan includes other activities such as (1) the development of safe work practices, (2) the use of environmental monitoring instrumentation, and (3) the use of personal protective equipment by MHCW personnel in order to minimize their exposure to potentially hazardous chemicals during their work activities. All of these activities are key elements of an industrial safety and hygiene program. It is these elements, described below as part of the enviromental monitoring plan, that will be merged with the medical monitoring plan and subjected to a trial implementation in Task IV.

II.1 Purpose of Environmental Monitoring

One aspect of the environmental monitoring plan, as described above is the measurement of the chemical concentration in the area where work is to be performed. The determination of concentration level is necessary to determine (1) the level of hazard associated with a particular work activity and chemical, and (2) the degree of personal protection which is required. When determining the level of hazard and the degree of personal protection, the following points should be considered:

- For any particular chemical, the potential for exposure may range from high to essentially non-existant depending upon the work activity to be accomplished. Although the chemical may be transported in liquid or solid form, the greatest potential for exposure to workers may be in the form of airborne vapors or dusts. Although a work activity may bring a worker into close proximity to a hazardous chemical, if toxic vapors or dusts are not formed by that particular chemical (for example, a liquid with a very low vapor pressure), then no reason for concern exists. Clearly, it is necessary to have some means to evaluate the hazard potential for each combination of work activity and chemical. Once the contaminant concentration is known, intelligent decisions can be made regarding the level of controls or protection necessary and/or effective.

- If the amount of air contamination in the work place exceeds acceptable levels, engineering controls should be used to prevent the atmospheric contamination (or to reduce it to an acceptable level).

- If effective engineering controls are not feasible, and if respiratory protection equipment is needed to prevent worker exposure to hazardous chemical vapors or dusts, then OSHA Standard 1910.134-Respiratory Protection requires that the employer establish and maintain a respiratory protective program. This requires that a written standard operating procedure be developed to specify the location of respirator use, the type of equipment to be used, the conditions that can be expected during normal respirator use, and emergency procedures to be followed. The respiratory protective program must provide for the training of personnel in the proper use, inspection, maintenance and storage of

respirators. Persons should not be assigned to work tasks that require the use of respirators unless they are physically able to perform the work and to use the equipment. Surveillance of the work area should be performed and the degree of worker exposure or stress should be observed. Also, regular inspections and evaluations should be carried out to determine the effectiveness of the respiratory protection program.

- If air purifying respirators are used (as part of a respiratory protection program) to prevent worker exposure to hazardous chemical vapors, it is important to be aware of the limitations concerning their use. Air purifying respirators have two modes of failure when used in high chemical vapor concentrations. These are (1) air (containing toxic vapor) seeping in around the face seal, and (2) insufficient quantities of adsorbent material in the air purifying cartridge or cannister to remove the toxic vapor.

- The "maximum use concentration" (MUC) for an air purifying respirator is determined by one or the other of these failure modes. The potential for air leakage around the face seal is accounted for by a "protection factor" (PF) assigned to each type of respirator. Then, one estimate for the maximum use concentration is MUC = PF * TLV-TWA where the TLV-TWA value is the Threshold Limit Value adopted by the ACGIH for a particular chemical. Another estimate for the MUC is a maximum allowable value for the chemical vapor concentration in the contaminated air to avoid adsorbent breakthrough in the air purifying cartridge. The actual MUC is determined as the lesser of these two estimates.

- As an example, the MUC for a half face mask air purifying respirator used as protection against inhalation of benzene vapor will be considered. The half face mask respirator has a protection factor of PF = 10 and a maximum allowable value for hydrocarbon concentration in air of 1000 ppm. The TLV-TWA value adopted by the ACGIH for 1984-85 is 10 ppm for benzene vapor. One estimate for the MUC is PF * TLV-TWA (or 10 * 10 ppm = 100 ppm). The other estimate is 1000 ppm, the maximum allowable hydrocarbon vapor concentration. The MUC is the lesser of these two numbers, 100 ppm. Thus, for the use of a half face mask respirator in air containing benzene vapor, the potential for air leakage around the face seal is the factor that determines the maximum use concentration.

II.2 Information Required for Environmental Monitoring

To carry out the Environmental Monitoring Program, some basic information is needed about the chemicals, the job activities, and the techniques available to eliminate potential exposure. In particular, the following types of information are needed to apply the Environmental Monitoring Program to a particular MHCW class.

- Data on the potentially hazardous substances that will be encountered in the work environment. The service of an industrial hygiene specialist should be obtained to review the hazard potential of all of the chemicals and potentially hazardous substances that are encountered in the work place. Many of these substances are included in the 46CFR Subchapter O list of potentially hazardous chemicals that are approved for shipment in bulk by water.

However, the list of hazardous substances should not be confined only to the Subchapter O chemicals. Some of the chemicals regulated by 46CFR Subchapter D are toxic, and may have a greater hazard potential in the work place than certain of the Subchapter O chemicals. Also, other potentially hazardous materials that are used in maintenance or cleaning operations should be considered. Silica used in sand blasting operations is an example.

Basic data concerning the toxic concentration limits such as the IDLH (Immediately Dangerous to Life and Health) level, and the TLV (Threshold Limit Value) or other permissible exposure limit is needed to determine the concentration limits for work place safety. Information about the route of hazardous material exposure is also needed in order to guide the selection of protective equipment and clothing. Some materials are readily absorbed into the body through the skin, while others enter the body primarily through vapor inhalation. Hazaardous materials with different routes of exposure require different methods of protection. Physical property information for the chemicals in liquid and vapor form is useful as supplemental information.

- <u>Descriptions of the work activities</u> performed by MHCW personnel that involve these hazardous materials. This information can be presented conveniently in the form of a Job Scenario which itemizes the work activities and highlights the operations which involve potential exposure to hazardous materials. The Job Scenario can be used as the basic data for the development of a Safe Work Practice.

- <u>Information about the instruments</u> that are available for measuring the concentration of potentially hazardous materials in the work place. For most of the MHCW classes, three types of instruments are needed. These are instruments for measuring (1) oxygen concentration, (2) chemical vapor concentration at the level of the lower flammability limit, and (3) chemical vapor concentration at the level of the Threshold Limit Value (TLV) for toxicity.

- While personal protective equipment can be used to eliminate exposure to hazardous materials, it should be viewed as a last level of defense. If the potential exposure can be prevented by other means, they should be investigated. Therefore, there is a need for <u>information about engineering control devices, and administrative control techniques</u> that will prevent potential exposures.

- <u>Information about personal protective equipment</u> that can be used to prevent exposure to potentially hazardous materials. Since these materials may have different routes of exposure, information is needed about (1) respiratory protection equipment, (2) eye protection, and (3) skin protection.

The information listed above is important for determining the potential for exposure to hazardous materials in the work place and the methods available to reduce or eliminate that potential. Another key element in an industrial hygiene program, is measuring the worker's actual occupational exposure to hazardous materials. This measurement is usually performed by an industrial hygiene specialist, using accepted methods of personal sampling for chemical exposure. Occupational exposure data is also of value to the environmental monitoring program. Exposure information can be used to assess the effectiveness of the control devices and techniques used in the work

place. If occupational exposure data shows that the worker's exposure exceeds the TLV or permissible exposure limit, then a review of the Safe Work Practice, control technology and techniques, and the possible use of protective equipment is required to reduce the occupational exposure to acceptable levels.

II.3 Resources Required for Environmental Monitoring

The information developed during the environmental monitoring program will lead to the selection of proper instrumentation, control devices and protective equipment. However, there are other requirements for equipment, facilities, and expert assistance that should be satisfied for smooth implementation of both an environmental monitoring and an industrial hygiene program. The resources needed to support these programs are listed below.

- Instruments for measurements of (1) oxygen concentration, (2) combustible vapor concentration, and (3) toxic vapor, mist or dust concentration for all of the hazardous materials encountered in the work place.

- Facilities for calibration and maintenance of the instrumentation.

- Personal protective equipment to prevent exposure to hazardous materials encountered in the work place.

- Facilities for fit testing workers for respirators and other protective equipment.

- Facilities for decontaminating, repairing, and storing the protective equipment.

- A source of supply for spare parts and expendable items. This is an important consideration for chemical tankerships and towboats that may travel long distances and be away from their home port for long periods of time.

- A training program to instruct the appropriate MHCW personnel in the use and care of instrumentation and protective equipment.

- A set of Safe Work Practices that describe how a job or operation can be performed safely without exposure to hazardous materials. When used in training and audits, these ensure that the instrumentation, control technology and techniques, and protective equipment are used effectively.

- Services of an industrial hygiene and analytical laboratory organization. This organization will furnish qualified industrial hygiene personnel, with access to qualified analytical laboratories, to perform occupational exposure monitoring, and provide guidance on health hazard prevention.

- Corporate management commitment to work place safety. This "resource" is very important, and it involves more than a commitment to spend money on safety equipment. Support of management at the work place supervision level is needed to enforce the Safe Work Practices, to identify instruments and control systems that need repair, to reorder equipment expended through normal use, and to conduct on-the-job training of MHCW employees.

II.4 Environmental Monitoring Devices

One of the Task II work activities involved an evaluation of the state-of-the-art devices for on-site environmental monitoring. During this task, information was gathered on many different types of instruments and devices for measuring oxygen concentration, combustible gas concentration, and toxic vapor concentration. Some of these devices are monitors designed to measure continuously, and to sound an alarm when the concentration passes a preset limit. Other devices are detectors that can sample, process and analyze a gas sample in a short period of time to determine the concentration. Still other devices are dosimeters, capable of adsorbing a chemical gas or vapor from the air over a long period of time, that are useful for occupational exposure monitoring.

The information on environmental monitoring devices has been assembled into a complete report, and appears as Volume II, Review of Environmental Monitoring Devices of the Task II Interim Report. This report volume contains the information on the environmental monitoring devices in tabular form in a series of appendices. Appendices A through I in the Volume II report contain listings (arranged by manufacturer and model number) of:

- o Passive dosimeters;
- o Active dosimeters;
- o Pumps (used in dosimetry);
- o Oxygen monitors;
- o Combustibility indicators;
- o Combination combustibility and oxygen monitors;
- o Active personal toxicity monitors;
- o Active portable toxicity monitors;
- o Passive personal toxicity monitors.

The report itself describes (1) how the tabular listings were developed, (2) how the devices were classified, and (3) what type of information is contained in the tables.

Although it was convenient to present the device information arranged by manufacturer and model number, it would be helpful to know what environmental monitoring devices are available for a specific Subchapter O or Subchapter D chemical. Therefore, a cross reference guide was developed that identifies the names of manufacturers that offer devices for different chemicals. The report also describes the general procedure to be followed in using the tabular listings for device selection, and presents an example for reference.

In addition, some valuable reference material, offered by environmental monitoring device manufacturers for use on this project, has been included in the Volume II report. This information is contained in Appendices J through L, and references A through C. The reference material contains the following information.

- o A selection chart for colorimetric detector tubes manufactured by the National Draeger Company for different chemical vapors. This chart was compiled in 1984, with updates compiled in 1985.

- o A selection chart for colorimetric detector tubes manufactured by the Gastec (Sensidyne) Company for different chemical vapors. This chart was compiled in 1984.

- o A cross reference chart for colorimetric detector tubes manufactured by Gastec, National Draeger, Mine Safety Appliances and Matheson-Kitagawa (Komyo). The chart was published by Gastec in 1980.

- o A guide to NIOSH/OSHA air sampling standards, compiled by the SKC Company. This guide was published in 1985.

- o The Pro-Tek* organic compound sampling guide for G-AA/G-BB badges, compiled by the E. I. DuPont Company. This guide was published in 1982.

II.5 Protective Equipment

It is generally accepted by industrial hygiene specialists that personal protective equipment should be used only as a last resort, when engineering controls to eliminate potential exposure to hazardous materials are not available or cannot be made adequate. However, there are several MHCW scenarios developed during Task I of this project, where personal protective equipment is used currently (although not uniformly throughout the industry) to prevent potential exposure to hazardous chemicals.

The recommendation and use of personal protective equipment does not mean that engineering control technology to eliminate potential exposure for the operations covered by the scenarios is not feasible. However, it does mean that engineering control technology was not available (or if available, simply not implemented) due to considerations of cost, reliability, or a concern for safety in case of system failure.

For most of the MHCW scenarios developed during Task I of this project, the primary route of exposure is by vapor inhalation. However, the potential for liquid splash onto the arms, hands and face, and into the eyes also exists for some of the scenarios.

The Occupational Safety and Health Administration (OSHA), and the American National Standards Institute (ANSI) have adopted standards that apply to the use of protective equipment. For example, OSHA-ANSI Z87.1-1979, Occupational and Educational Eye and Face Protection, is a standard that applies to the use of protective eyewear. Goggles used to protect the eyes from chemical splash should comply with OSHA-ANSI Z87.1-1979.

OSHA Standard 1910.134 - Respiratory Protection, covers the use of respirators to prevent inhalation of vapors, mists, dusts and fumes. ANSI Standard Z88.2-1980, Practices for Respiratory Protection, presents a set of accepted practices for respirator users and provides information and guidance on respirator selection.

The OSHA-ANSI standards are very useful, and they should be used for guidance when programs for the use of protective equipment are developed.

In addition to the OSHA-ANSI standards, there are guides to the selection and use of protective clothing, and respiratory protection that are particularly helpful.

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* Pro-Tek is the E. I. DuPont Company's registered trademark for its organic vapor air monitoring badges.

- Guidelines for the Selection of Chemical Protective Clothing* contains comprehensive tables of recommendations to aid the selection of chemical protective clothing including gloves, coveralls, pants, jackets, and boots. Volume I of the Guidelines presents two "Matrices" for the selection of protective clothing. Matrix A presents chemical protective clothing recommendations for approximately 300 chemicals and fourteen clothing materials. Matrix B provides chemical protective clothing recommendations for the same fourteen materials, but presents them for generic families of chemicals.

  The Guidelines note that (1) no plastic or elastomeric clothing is "impermeable", (2) each chemical interacts with a given plastic or elastomer differently, (3) no one clothing material will be a barrier to all chemicals, and (4) for certain chemicals or combinations of chemicals, there is no commercially available glove or clothing that will protect the wearer against chemical breakthrough for a period of one hour following the start of continuous contact.

  The recommendations for chemical protective clothing materials given in the Guidelines should be used as a basis for materials selection rather than chemical resistance ratings charts given in clothing manufacturers' catalogs. Clothing manufacturers' catalogs, while they do give some good information in some cases, should be used primarily for information about sizes, styles and materials of construction for their products.

- Respiratory Protection, A Manual and Guideline** was published to provide enough information to establish and operate a program involving respiratory protective equipment. It identifies the types of jobs that may require respiratory protection, and provides information for selecting respirators for most of these operations. The Manual describes the different types of respiratory protective equipment that can be used. (ANSI Standard Z88.2-1980 should also be consulted for a complete categorization and description of the different types of respirators.

  (1) Mechanical filter respirators for protection against airborne particulate matter, such as dusts, mists, metal fumes and smokes.

  (2) Chemical cartridge respirators for protection against low concentrations of organic vapors and gases, alkaline gases, acid gases, mercury vapors, pesticides, paint vapors and mists, organic vapors or gases combined with acid or alkaline gases, and any of the above combined with dusts, fumes or mists.

  (3) Cannister respirators for protection against high concentrations of organic vapors or gases, alkaline gases, pesticides, paint vapors and mists, radioactive particulates, dust, mists, fumes and certain other combinations of these materials. Gas masks may be used for escape from IDLH atmospheres, but not for reentry into such atmospheres.

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* Prepared by Arthur D. Little, Inc. for the Los Alamos National Laboratory under the sponsorship of the U.S. Environmental Protection Agency. Published in 1983 by the American Conference of Governmental Industrial Hygienists, Inc. (ACGIH), 6500 Glenway Ave., Bldg. D-5, Cincinnati, OH 45211.

** Prepared by L. R. Birkner of the Celanese Corporation. Published in 1980 by the American Industrial Hygiene Association, Akron, OH.

(4) Air-line respirators for protection against all airborne contaminants in concentrations that do not exceed the IDLH. Air-line respirators can also be used in some oxygen deficient atmospheres if the air-line respirator has an escape mode.

(5) Self-contained breathing apparatus for protection in oxygen deficient environments and in situations where high or unknown concentrations of toxic gases, vapor or particulates are present. The SCBA is also used in emergency operations such as rescue from enclosed spaces.

(6) Powered air-purifying respirators for protection against particulates and/or gases and vapors. These are used in applications such as abrasive blasting, grinding, pesticide spraying and operations involving asbestos.

(7) Supplied air suits for complete isolation from the work environment.

The Manual also provides information about protection factors and the Maximum Use Concentration (MUC) and gives guidelines for the use of each of these types of respirators. Sections of the manual also cover training, qualitative and quantitative fit testing, and inspection, cleaning, maintenance and storage.

The information in the AIHA Respiratory Protection Manual is very helpful, particularly the guidelines on Maximum Use Concentration for each type of respirator. Currently, the three types of respiratory protective equipment that are used most frequently in MHCW work activities are (1) the chemical cartridge respirator (both half facepiece and full facepiece style), (2) the gas mask (a full facepiece style respirator), and (3) the positive pressure SCBA (also a full facepiece respirator).

For the half facepiece style chemical cartridge respirators, the protection factor is 10. Therefore, the MUC is 10 times the TLV (or other permissible exposure limit) or 1000 ppm, whichever is lower.

For the full facepiece chemical cartridge respirator, the protection factor is 100. Therefore, the MUC is 100 times the TLV or 1000 ppm, whichever is lower.

Neither style of chemical cartridge respirator can be used in environments containing less than 19.5% oxygen. It should be noted that the full facepiece respirator also provides protection to the eyes against chemical splash hazards. To prevent fogging of the eyepiece, it is recommended that a "nose cup" be fitted to the inside of the full facepiece respirator. The half facepiece style of respirator provides no eye protection, and may have to be worn together with goggles where both eye and inhalation protection is needed. Fog proof goggles should be specified in warm, and humid climate conditions.

For the full facepiece gas mask, the sorbent chin-type cannisters may be used in concentrations up to 5000 ppm, and the industrial size cannisters in concentrations up to 20,000 ppm (2%). However, the MUC for the respirator will probably be determined by the protection factor, which is dependent upon the type of mask fitting method used. If a qualitative fit method is used, the protection factor is 100. If a quantitative fit method is used, the protection factor may be increased to 1000. While full facepiece respirators are capable of giving good protection against toxic gases or vapors, they must never be used in environments containing less than 19.5% oxygen.

Full facepiece respirators also provide eye protection. A "nose cup" should be used with the gas mask to prevent fogging of the eyepiece in warm, humid climate conditions.

The positive pressure type of SCBA can be used in oxygen deficient atmospheres, and in vapor concentrations that exceed the IDLH level. The protection factor for a positive pressure SCBA is 10,000, although a higher protection factor is permitted if quantitative fit testing is performed for the individual wearing the SCBA.

The Respiratory Protection Manual stresses the importance of using the correct cartridge or cannister with either chemical cartridge respirators or gas mask. USING THE WRONG CARTRIDGE OR CANNISTER MAY BE LIKE USING NO RESPIRATOR AT ALL. For example, an acid gas cartridge cannot be used for protection against organic vapors like benzene. However, a combination acid gas and hydrocarbon cartridge will protect against either one or both types of contaminant.

A standard has abeen developed (ANSI K13.1-1973) for color coding the labels of chemically adsorbing cartridges and cannisters. The color of the label identifies the types of atmospheric contaminants that the cartridge or cannister provides protection against. For example, cartridges that protect against acid gases are color coded white, while cartridges that protect against organic vapors are color coded black. Cartridges that protect against both acid gases and organic hydrocarbon vapors are color coded yellow. The Color Code for Cartridges and Gas Mask Cannisters is reproduced in Section IX of the Respiratory Protection Manual.

The Respiratory Protection Manual also lists the names and addresses of both manufacturers and distributors of NIOSH/MSHA approved respiratory protective devices. It should be noted that the OSHA Standard 1910.134-Respiratory Protection requires that equipment approved by NIOSH/MSHA be used.

The Guidelines for the Selection of Chemical Protective Clothing also identifies the manufacturers and distributors of chemical protective clothing.

It is clear that a company or an organization that wishes to provide protective equipment to its employees must have information about the nature of the exposure that the protective equipment should prevent. Making the correct choice of protective equipment is not simple, particularly since a worker who is not accustomed to wearing the equipment is likely to find it uncomfortable. Protective equipment should be field tested to evaluate its effectiveness, and to determine whether it interferes with the worker's ability to carry out his job activities. It will be helpful to retain the services of a qualified industrial hygienist to assist with the set-up and evaluation of a personal protective equipment program.

III. APPLICATION OF ENVIRONMENTAL MONITORING TO MHCW SCENARIOS

The basic elements to an environmental monitoring plan are the following.

- Identify the hazardous chemicals and materials that are encountered in the work place. This includes chemical cargos, and potentially hazardous materials used in repair and maintenance operations.

- Identify the work activities and operations that may expose MHCW personnel to hazardous materials.

- Obtain data about the hazard potential of these materials, and the instruments available to measure concentration, and the procedures and equipment available to protect personnel from exposure.

- Analyze the work activity, and determine how it can be performed safely. Develop a Safe Work Practice that outlines the procedures to be followed for preventing exposure to hazardous materials.

- Obtain the instrumentation and equipment specified for use in the Safe Work Practice. Provide facilities for calibration, maintenance, and storage of instruments and equipment.

- Train MHCW personnel using the Safe Work Practice to perform their work activity safely. Provide specific training in the use and care of instrumentation and protective equipment.

- Enforce the safe performance of the work activity by periodic re-training and Safe Work Practice audits.

This description is very general, and it can be applied to any MHCW scenario. However, to illustrate how the environmental monitoring plan would work, it was necessary to apply it to several of the MHCW scenarios and to perform a limited field test.

Section III.1 describes the selection of chemicals for consideration during implementation of the environmental monitoring plan. Section III.2 discusses the MHCW scenarios, and how scenarios were selected for the field test. Section III.3 shows how the environmental monitoring plan can be applied to the scenarios and presents examples of Safe Work Practices for some of the scenarios. The results of the field test evaluation of Safe Work Practices are summarized in Section IV. Full field test reports are contained in Appendices C, D, and E. Finally, some recommendations to be considered for a full implementation of the environmental monitoring plan are contained in Section V.

III.1 Identification of Chemical Cargos

The first step in the environmental monitoring plan is to identify the potentially hazardous materials that will be encountered in the work place. This step is important because the rest of the environmental monitoring plan involves additional steps to prevent the exposure of MHCW personnel to these materials.

For the Task II field tests of the environmental monitoring plan (described in Chapter IV), a specific set of chemicals was selected. The U.S. Coast Guard regulates the bulk shipment of these chemicals by water under 46CFR Subchapter O. These chemicals are classified in Subchapter O because of their potential for toxicity, corrosiveness or reactivity with other chemicals.

The Coast Guard also regulates the bulk shipment by water of another set of chemicals under 46CFR Subchapter D. The Subchapter D chemicals are primarily flammability hazards rather than toxic, corrosive or reactive hazards. Although this report deals mainly with Subchapter O chemicals, due to the high inherent toxicity, past work* indicates that a few of the Subchapter D chemicals are highly toxic, while others (such as gasoline) have sufficiently high vapor pressures to cause significant exposures under common circumstances. Appendix A contains a list of chemicals regulated under both Subchapter D and O.

The set of Subchapter O chemicals was selected for consideration in the Task II field tests because it contains most of the chemicals that have a high health hazard potential. As discussed in Appendix A, the National Academy of Sciences has reviewed the health hazard potential for many of the chemicals whose shipment is regulated by the U.S. Coast Guard. The set of Subchapter O chemicals contains chemicals that received health hazard ratings of 2, 3, and 4 on a scale of 0 (not hazardous) to 4 (severely hazardous).

An independent assessment of vapor toxicity hazard potential was conducted by SwRI personnel. This assessment sought to rank all of the Subchapter D and O chemicals in terms of the ratio of vapor pressure (Cs in Appendix A) to TLV, (the ACGIH threshold limit value). Nearly all of the chemicals with ratios Cs/TLV greater than 1000 belong to the set of Subchapter O chemicals. Conversely, most of the chemicals with ratios less than 1000 are Subchapter D chemicals. Several Subchapter O chemicals with values of Cs/TLV less than 1000 are corrosive or reactive hazards.

However, it should be pointed out that there are examples of Subchapter D chemicals (chemicals that are primarily flammable) that could be added to the list of Subchapter O chemicals to form a more complete list of potentially hazardous chemical cargos. Two chemicals currently regulated under Subchapter D have NAS health hazard ratings of 4 because they are poisons. These are caprolactam solution (Cs/TLV = 2600), and hexylene glycol (Cs/TLV = 2.6). Two other chemicals currently regulated under Subchapter D have values of Cs/TLV that exceed 1000. These are methyl acetate (Cs/TLV = 1100), and hexane (Cs/TLV = 2400). Three other chemicals regulated under Subchapter D have values of Cs/TLV that are close to 1000. These are methyl alcohol (Cs/TLV = 650), methyl ethyl ketone, (Cs/TLV = 650), and n-pentane (Cs/TLV = 950).

Very few MHCW personnel are likely to encounter all of these potentially hazardous chemicals. Companies that manufacture and transport petrochemical products ship a mixture of Subchapter D and a few Subchapter O chemicals on a regular basis. Companies that operate chemical tankerships for charter ship a larger number of Subchapter O chemicals, but they may not ship the same hazardous cargos

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*W. J. Astleford, J. C. Buckingham, H. L. Kaplan, R. J. Magott, J. P. Riegel, "A Crew Exposure Study - Phase II, Volume II - At Sea", Parts A & B, Final Report on Contract DTCG23-80-C-20025, Southwest Research Institute, San Antonio, Texas, April, 1985.

on a regular basis. Tow boats haul barges that contain both Subchapter O and D chemicals, but a tankerman working with the boat may not be involved in the loading of Subchapter O chemicals very frequently.

It is suggested that companies or organizations that want to eliminate the potential for exposure of MHCW personnel to hazardous materials review the list of chemicals in Appendix A. Any chemicals encountered by their employees should be noted in a separate list that is specific to their operations. Any other potentially hazardous substances such as silica (sand blasting) that may be used in routine maintenance operations should also be added to this list. The assistance of an industrial hygiene specialist will be helpful both in identifying potentially hazardous substances, and in developing an industrial hygiene program to prevent worker exposures to these substances.

III.2 Identification of MHCW Scenarios

After the list of potentially hazardous chemicals and materials has been compiled, a review should be made of all of the operations performed in which MHCW personnel encounter these substances. The job activities performed by individuals during these operations should be observed and described. During Task I of this project, observations were performed, and job scenarios were written to describe many of these operations.

A list of the MHCW job scenarios appears in Appendix B. Preliminary versions of the scenarios have been transmitted to the Coast Guard in progress report letters. A Task I report including the final, updated versions of the scenarios is expected to be published before the project is concluded.

An organization that intends to implement the environmental monitoring plan should review the MHCW scenarios developed during Task I to determine how many of the scenarios apply to its operations and activities. Then additional scenarios that are specific to these operations can be developed in a similar manner.

One of the Task II activities involved selecting a set of about six scenarios for field test evaluations of the environmental monitoring plan.

III.2.1 Merchant Marine - Barges

The Task I scenario development (see Section B.1) identified barge loading and barge cleaning operations as activities that involved the greatest potential for exposure to hazardous chemicals. SwRI contacted a company that transports both Subchapter O and D chemicals by barge for cooperation with the field test evaluations. This company has a safety policy that prohibits its employees from entering cargo tanks for any reason. Therefore, the two scenarios selected for the field test, involve activities that take place during barge loading operations. These are (1) tank top-off during open loading, and (2) hose disconnect following either loading or discharge.

Section B.2 presents a job scenario developed during Task I for both the tank top-off during open loading and the hose disconnect activities. Occupational exposure monitoring was also performed during the scenario observation. Note that the personal exposure to methanol vapor was just below the TLV-STEL value of 250 ppm during the top-off operation. A plastic face shield for eye protection was used, but no respiratory protective equipment was worn during top-off.

III.2.2 U.S. Coast Guard Personnel

The scenario list in Section B.1 includes scenarios for Marine Inspection Office (MIO) personnel performing barge and tanker inspections, Captain of the Port (COTP) personnel performing pollution prevention and pollution response activities, members of the pollution response Strike Force Teams, and independent Admeasurers.

Although pollution response involves a significant potential for exposure to hazardous chemicals, it was not possible to schedule an actual response activity. Therefore, the scenarios selected for the field test evaluation involved activities that are performed routinely by MIO and COTP personnel. Three scenarios were selected for the field test. These are (1) COTP pollution prevention survey, (2) MIO barge inspection, internals and void spaces, and (3) MIO tanker inspection, biennial or Letters of Compliance (LOC). Section B.3 contains a MHCW job scenario developed for each of these activities for reference.

III.2.3 Merchant Marine - Tank Vessels

Section B.1 lists several different MHCW scenarios that are performed on chemical tankerships. The scenarios that appeared to offer the greatest potential for exposure to hazardous materials involved the operations of cargo loading and cargo tank entry. A company that transports both Subchapter O and D chemicals by tankership was contacted and agreed to participate in the field evaluation. Two scenarios were selected for evaluation. These are (1) tank entry for preloading inspection, and (2) tank top-off during open loading. The MHCW job scenarios for each of these activities appear in Section B.4.

III.3 Environmental Monitoring Plan for MHCW Scenarios

The same approach was taken in applying the environmental monitoring plan to the scenarios selected for the field test evaluation. The key steps are listed below.

- o Review the job scenario, and use it to draft a preliminary version of a Safe Work Practice.
- o Compile data on flammability and toxicity hazards needed to select environmental monitoring devices (see Appendix A).
- o Identify instruments and protective equipment needed to implement the Safe Work Practice.
- o Review the preliminary version of the Safe Work Practice with members of the organization or company that are cooperating with the field test evaluation.
- o Coordinate the availability of environmental monitoring instrumentation and protective equipment with the cooperating company or organization. Order any equipment that is needed for the field test, but is not currently available to the MHCW personnel participating in the field test.
- o Fit test and train the MHCW personnel in the use of the protective equipment when necessary.
- o Coordinate the Safe Work Practice evaluation to the job activity. Direct the use of protective equipment and environmental monitoring instrumentation.

SwRI personnel were present during the field test evaluation to perform (or to provide assistance with) the last two functions listed above. This function is normally performed by regular members of the operations supervision team.

III.3.1 Merchant Marine - Barges

The Safe Work Practices for the barge operation scenarios are included as part of the field test report in Sections C.4 and C.5. The Safe Work Practices and a consideration of the chemical cargos that were likely to be encountered during the field test identified the following requirements for protective equipment.

Hose disconnection

- Half facepiece chemical cartridge respirataor
- Hydrocarbon vapor cartridge for respirator
- Chemical goggles to be worn with the respirator
- Impervious gloves (PVC or neoprene)
- No requirements for environmental monitoring devices

Tank top-off during open loading

- A full facepiece chemical cartridge respirator, or
- A half facepiece chemical cartridge respirator
- Chemical goggles for some chemicals
- Impervious gloves (PVC or neoprene)
- No requirements for environmental monitoring devices

During discussions with the cooperating company, it was learned that they favored the use of a full facepiece respirator to prevent exposure to hazardous chemical vapors. During the field test, a problem was experienced with fogging of the eyepiece of the full facepiece respirator (the problem was later eliminated by inserting nose cups into the respirator). Therefore, the use of a half facepiece respirator together with chemical goggles was evaluated during the field test. All of the protective equipment used during the test was furnished by SwRI. Environemtal monitoring instrumentation was not required by the Safe Work Practices.

The results of the field test evaluation are summarized in Section IV.3.1, and are described completely in the field test report in Appendix C.

III.3.2 USCG Personnel

The Safe Work Practices for the three USCG scenarios are included in the field test report in Sections D.4, D.5, and D.6. The Safe Work Practices identified the following requirements for environmental monitoring instrumentation and protective equipment.

COTP pollution prevention survey

- Half facepiece chemical cartridge respirator
- Hydrocarbon vapor cartridge for respirator
- No requirements for environmental monitoring devices

MIO barge internal inspection

- Impervious gloves
- O_2/CGI monitor to warn of oxygen deficiency, or combustible gas hazard while inside the tank

MIO tanker LOC inspection

- No requirements for chemical protective clothing or equipment
- No requirements for environmental monitoring devices

The Safe Work Practice for Coast Guard marine inspectors performing barge internal inspections requires that the cargo tanks or void spaces to be inspected are certified as SAFE FOR WORKERS by a certified Marine Chemist. The Safe Work Practice for marine inspectors performing a tanker Letters of Compliance (LOC) inspection requires that any enclosed pump room or space which may contain hazardous vapors must be ventilated and tested for oxygen, combustible gas, and toxic gas concentration by the Master of the vessel before the inspector can enter the room.

The protective equipment and environmental monitoring devices were furnished by SwRI for the field test evaluation.

The results of the field test evaluation are summarized in Section IV.3.2, and are described completely in the field test report in Appendix D.

III.3.3 Merchant Marine - Tank Vessels

The Safe Work Practices for the tank vessel scenarios evaluated during the field tests are included in the field test report in Sections E.4 and E.5. The Safe Work Practice and a consideration of the chemicals likely to be encountered identified the following requirements for protective equipment and environmental monitoring devices.

Tank entry for preloading inspection

- O_2/CGI for measuring oxygen and combustible gas concentration
- Toxic vapor detector system
- SCBA
- Chemical protective suit (if contact with chemical residue is likely)
- Impervious gloves (if contact with chemical residue is likely)

Tank top-off during open loading

- Full facepiece chemical cartridge respirator
- Hydrocarbon vapor cartridges for respirator
- Chemical protective clothing (if the vapor irritates the skin)
- Impervious gloves
- No requirements for environmental monitoring devices

All of the protective equipment and all of the environmental monitoring devices used in the field test evaluation were furnished by the vessel. In addition, the officers of the vessel provided the supervision of environmental monitoring and directed the use of protective equipment.

The results of the field test evaluation are summarized in Section IV.3.3, and are described completely in the field test report in Appendix E.

IV. FIELD TEST OF THE ENVIRONMENTAL MONITORING PLAN

As stated in Section II, the goal of the environmental monitoring program is to minimize the exposure of MHCW personnel to hazardous chemicals during their work activities. The environmental monitoring plan includes several different activities:

- development of Safe Work Practices for MHCW scenarios that may expose MHCW personnel to hazardous chemicals;
- using environmental monitoring devices to determine if work can be performed safely;
- using personal protective equipment during work activities to prevent exposure.

The information and equipment needed to support the environmental monitoring plan was discussed in Section II. Also, the general approach to applying the environmental monitoring plan to the MHCW scenarios was described in Section III.

To illustrate the operation of the environmental monitoring plan, a set of field tests were performed. Trip reports describing the field tests are contained in Appendices C, D, and E. This section describes the work leading up to the field tests and summarizes the results.

IV.1 Field Test Objectives

The objectives of the field tests were to:

- assess the practicality of applying the environmental monitoring plan to several selected MHCW job scenarios;
- assess the effectiveness of the environmental monitoring plan in eliminating potential exposures to hazardous chemicals;
- determine what problems arise in applying environmental monitoring;
- obtain feedback information from the MHCW personnel participating in the field test to assess their acceptance of the environmental monitoring plan.

IV.2 MHCW Scenarios Selected for Field Tests

The MHCW scenarios (presented in the Task I final report) describe many of the operations and job activities performed by MHCW personnel. These scenarios were reviewed to select candidates for the field test evaluation. Scenarios were desired from three MHCW categories: (1) merchant marine on barges; (2) merchant marine on tankerships; and (3) USCG personnel. The criteria for selecting scenarios for the field tests were the following:

- scenarios should occur routinely and involve a real potential for exposure to hazardous chemicals;
- the operation or job activity described by the scenario should be easy to schedule (activities such as chemical spill response were excluded);

- the environmental monitoring plan should provide for the use of instrumentation and or personal protective equipment.

The final set of scenarios selected for the field test evaluation met all of these criteria. The scenarios are:

- Merchant Marine - Barge Tankerman Operations
  - (1) Transfer hose disconnection from barge to shore
  - (2) Open tank top-off
- U. S. Coast Guard Personnel
  - (1) COTP, Pollution prevention survey
  - (2) MIO, Barge inspection (internal and void spaces)
  - (3) MIO, Biennial/LOC tanker inspection
- Merchant Marine - Chemical Tankership Operations
  - (1) Tank entry for internal inspection
  - (2) Open tank top-off.

IV.3 Summary of Field Test Results

All of the environmental monitoring field tests were carried out during the months of March and April, 1985. For each MHCW class, about one week was allocated to field test performance. Preparation for the field tests began during the summer of 1984. Companies and organizations whose employees perform the desired operations and job activities were identified, and contacted to solicit their voluntary participation in the Task II project activity.

Discussions were held by telephone or in person with the companies and organizations that agreed to participate in the field tests. These discussions identified (1) which MHCW work activities were performed routinely, (2) the chemicals involved in these activities, (3) what types of protective equipment were furnished to MHCW personnel for use during work activities, and (4) current safety practices or instructions that covered these work activities.

Preliminary versions of Safe Work Practices were developed by SwRI project personnel for each of the field test scenarios. These Safe Work Practices were submitted to the participating companies and organizations for review by members of their staff representing Safety and Operations. Comments were received by SwRI and taken into account during preparation of revised Safe Work Practice for the field tests.

For each MHCW scenario, the type of instrumentation and personal protective equipment required by the Safe Work Practice was reviewed with the cooperating company or organization. If the necessary instrumentation and equipment was not currently available for use in the work place, then it was provided by SwRI.

During the field test, an SwRI project team member was on hand to provide advice on instrumentation and protective equipment, and to observe the work activity. In some cases, the Safe Work Practice was found to be incomplete. Notes were taken to describe the missing "steps" for inclusion in the final version of the Safe Work Practice.

IV.3.1 Merchant Marine - Barge Tankerman

The two operation scenarios selected for the field tests were:

(1) transfer hose disconnection from barge to shore;

(2) tank top-off during open loading of cargo.

Safe Work Practice evaluations for the transfer hose disconnection scenario were performed during two cargo transfer operations: discharge of acetone cyanohydrin, and the loading of benzene. Safe Work Practice evaluations for the tank top-off scenario were performed during four cargo transfer operations: loading of toluene, loading of vinyl acetate, loading of methyl alcohol, and loading of benzene. The final versions of the Safe Work Practices (revised after the field tests were completed) are presented in Appendix C.

Both the hose disconnection and the open loading tank top-off operations are performed outdoors, in the open air. For each of these work activities it was assumed (based on Task I scenario observations) that a potential exposure to cargo liquid and vapor was possible during the operation. The tankerman performing these operations were aware of the potential for chemical exposure, and they attempted to avoid contact with chemical liquid and to stand out of the way of chemical vapor plumes.

The Safe Work Practices for these operations do not require measurements of cargo vapor concentration in the work place. However, since exposure to potentially hazardous chemicals is possible for these job activities, personal protective equipment is required by the Safe Work Practices.

It should be noted that at both facilities where hose disconnection was observed, the flexible hose was purged with nitrogen following cargo transfer to minimize the amount of liquid left in the hose. This procedure is used as a control technique for minimizing the tankerman's exposure to hazardous chemical liquid.

The Safe Work Practice for hose disconnection (see Section C.4) requires the tankerman to wear impervious gloves, goggles, and an air purifying respirator (if the chemical in the hose is potentially toxic by vapor inhalation). For the acetone cyanohydrin operation, the tankermen wore gloves and goggles to prevent skin contact with the chemical liquid. A respirator was not worn because company operations and safety staff had determined (through occupational exposure measurements) that the tankermen were not exposed to significant amounts of acetone cyanohydrin vapor during their operations. The tankerman who assisted the dockman during hose disconnection following benzene loading did wear a half facepiece respirator and goggles. The protective equipment used by the tankermen did not interfere with their ability to do their job.

The Safe Work Practice for tank top-off during open loading (see Section C.5) requires the tankerman to wear an air purifying respirator (if the chemical vapor is potentially toxic by vapor inhalation), goggles (if the vapor is irritating to the eyes), and

gloves (if the tank is gauged by hand). Both full facepiece respirators and half facepiece respirators, with and without goggles, were evaluated during the field test.

The tankermen were not accustomed to wearing respirators during cargo loading operations. From the standpoint of comfort, tankermen preferred the half facepiece respirator, and goggles (when required) to the full facepiece respirator. A problem was experienced with fogging of the eyepiece for the full facepiece respirator. The tankerman had to remove the respirator in order to gauge the tank visually. This problem can be prevented by installing a nose cup into the respirator to capture exhaled air and direct it to the exhalation port. Except for the fogging problem with the full facepiece respirator, the protective equipment used by the tankermen did not interfere with their work during tank top-off.

The field test evaluation for barge tankermen identified some practical problems that will affect the implementation of an environmental monitoring program.

- Tankermen who are required to wear respiratory protective equipment must be properly fitted and tested. One size and style of respirator will not fit all tankermen. A properly fitting respirator that does not have to be re-adjusted frequently, or held in place with the hands, is essential to proper protection.

- All protective equipment should be field tested to determine if it interferes with the tankerman's ability to do his job. The problems encountered during the field test with fogging of the respirator eyepiece, and muffling of the voice by the respirator should be eliminated before the equipment is put into general use.

- Facial hair prevents a respirator from sealing properly against the face. Several tankermen wear beards, and they are reluctant to shave them off. However, the OSHA Standard 1910.134 states that respirators **shall not be worn** when conditions (such as **a growth of beard**, sideburns, a skull cap that projects under the facepiece, or temple pieces on glasses) **prevent a good face seal.** A company that intends to establish a respiratory protection program that is in compliance with OSHA 1910.134 will have to enforce a "clean shaven" policy for tankermen who wear respirators. When a tankerman is fitted and provided with an air purifying respirator, he should be taught that a tight face seal is important to prevent him from breathing contaminated air.

- The tankerman should be informed by his employer when a cargo transfer operation will require him to wear protective equipment. The tankerman should be reminded to wear his respirator and he should be told which chemical cartridge to use. This information could be transmitted by radio to the boat captain together with other instructions concerning the cargo transfer operation to be performed.

The field test evaluation also revealed a lack of uniformity on the part of marine terminal operators in applying their Safe Work Practice rules for personal protective equipment to barge tankermen (who are not employees of the marine terminal company). One major marine terminal operator now requires barge tankermen to wear the same level of personal protective equipment as their dockmen wear during the loading of certain Subchapter O chemical cargos.

However, we observed that another marine terminal operator that requires its employees to wear respirators while on a barge or in the loading dock area during benzene loading, did not enforce their safety policy requiring respiratory protection on a

barge tankerman working on the barge. This observation was surprising, because the marine terminal operating company requires that both employees and non-employees be clean shaven, and receive training on emergency procedures before they are allowed on company premises. In this instance, the barge tankerman wore a beard (which violates the clean-shaven policy), and he did not receive the same training in emergency procedures that the SwRI observer was required to have before entering the marine terminal area.

There doesn't appear to be any technical justification for requiring shore tankermen to wear respiratory protection, while allowing tow boat tankermen who must remain with their barge at all times during loading to be unprotected. Also, there isn't any justification for not requiring a tankerman to wear a respirator during open loading at one terminal, while requiring that a respirator be worn at another terminal. A barge tankerman is just as likely to be exposed to chemical vapors during a hose disconnection or an open loading at one facility as at another.

Unfortunately, the lack of uniformity from one company to another in requiring barge tankermen to comply with dock and marine terminal safety policies is confusing to the tankermen. When a marine terminal operating company doesn't require them to wear respiratory protection during the open loading of benzene, they doubt that they really need to wear a respirator. Also, they may develop animosity towards a company that does require them to wear a respirator. It would be helpful if marine terminal operators would agree to enforce their safe practices for marine terminal operations on tankermen who arrive by water just as they are enforced on tanker truck drivers, or visitors who enter the terminal area by land.

IV.3.2 U.S. Coast Guard MIO and COTP Personnel

Three operation scenarios were selected for the field tests.

(1) COTP, Pollution Prevention Survey

(2) MIO, Barge Inspection (internal and void spaces)

(3) MIO, LOC or Biennial Tanker Inspection.

A field test evaluation of the Safe Work Practice for the first scenario was performed while boarding teams inspected barges during the open loading of methanol, naphtha, #2 fuel oil, and para-xylene, and during the discharge of ethylene dichloride. A Safe Work Practice evaluation for the second scenario was conducted during an inspection of a barge that had carried glutaraldehyde. The field test for the third scenario involved an LOC inspection of a foreign flag vessel that carried LPG and chemical products. After the field tests were completed the Safe Work Practices were revised. The final versions of the Safe Work Practices are presented in Appendix D together with the field test trip report.

The pollution prevention surveys are generally of very short duration (about 15 minutes). During the survey, cargo transfer operations are allowed to continue uninterrupted, unless a violation of Coast Guard regulations is discovered. Then the transfer operation is halted until the violation is corrected.

The primary source of potential exposure to hazardous chemicals is the plume of cargo vapor emitted from cargo tank vents during open loading. One of the boarding team members checks to see that flame screens are in place, and that they are intact and not punctured. To check the flame screens, the inspector must come close to the open vent, and may be exposed to the vapor plume.

The Safe Work Practice in Section D.4 requires the boarding team to wear air purifying respirators if they board a barge that is open loading a Subchapter O or D chemical that is toxic by vapor inhalation. Eye protection, and skin protection are not required.

An alternative to this requirement for respiratory protection is to have the tankerman and the marine terminal suspend the open loading operation for the duration of the pollution prevention survey. This type of administrative control measure would be effective in eliminating the potential exposure to toxic vapors that exists during open loading. However, it would require a change in the operating procedure now used by the boarding team.

During the field test, an open loading operation involving a Subchapter O chemical was not observed. However, members of the survey team were requested to wear half facepiece chemical cartridge respirators during their inspection. No problems were encountered with the respirators, and they did not interfere with the inspectors as they completed their survey.

The Safe Work Practice for the barge internal inspection scenario requires that the tank and void spaces be certified as SAFE FOR WORKERS by a licensed Marine Chemist. It also requires that the tank and void space are ventilated while the inspection takes place. If these requirements are satisfied, respiratory protective equipment should not be needed. However, the Safe Work Practice does require the inspector to carry an O_2/CGI monitor with him into the tank as a safeguard against an unexpected occurrence. The Safe Work Practice requires the inspector to wear impervious gloves if contact with liquid chemical residue is likely.

The field test involved an inspection of both a main cargo tank and a wing void space. Both enclosed spaces had been tested and certified SAFE FOR WORKERS by a Marine Chemist. The inspector wore impervious gloves, and an O_2/CGI monitor was used to measure oxygen and combustible gas concentration during the inspection. No problems were experienced, except that the size of the O_2/CGI instrument made it somewhat harder to enter and exit the tank through the man openings.

The preferred scenario for the MIO tankership inspection was a biennial inspection which involved an internal inspection of the cargo tanks. Unfortunately, the opportunity to observe a biennial inspection did not arise, and an LOC inspection was observed instead.

Discussions with the marine inspectors suggested that an LOC inspection can usually be performed safely without the need for protective equipment or environmental monitoring devices. Cargo transfer activities are halted during an LOC inspection, and the inspectors are not usually exposed to plumes of cargo vapor. The inspectors observed that the main source of potential exposure to hazardous cargo vapors will occur during an inspection of a pump room (many new vessels have deep well pumps for each tank, and do not have cargo pump rooms). On vessels with pump rooms, their practice is to request that the Master have the room ventilated and tested for oxygen, combustible gas and toxic vapors before it is inspected.

No significant problems were encountered during the field test evaluation of the environmental monitoring plan for USCG scenarios.

IV.3.3 Merchant Marine - Tankership Crewmen

Two operational scenarios were selected for the field tests for tankership crewmen. These were

(1) tank entry for internal inspection, and

(2) tank top-off during open loading of cargo.

The Safe Work Practice evaluations were carried out on a parcel chemical tanker that routinely transports a combination of Subchapter O and Subchapter D chemicals.

The tank entry for inspection evaluation was performed during an inspection of a cargo tank that had transported methyl iso-butyl ketone, a Subchapter D chemical. The field tests for tank top-off during open loading were performed during loadings of three Subchapter O chemicals, ethylene dichloride, epichlorohydrin, and an ethylenediamine mixture. The Safe Work Practices were revised after the field tests to include activities omitted in the preliminary version. The final versions of the Safe Work Practices appear in Appendix E.

The tank to be inspected had been washed, gas freed, and manually cleaned before the vessel arrived at the marine terminal. The purpose of the tank entry inspection was to obtain wall washing samples to be analyzed for the presence of residual hydrocarbons or chlorides. This test was used to ensure that a cargo with critical purity requirements will not be contaminated by residue from the previous cargo.

When the vessel is at sea, a Marine Chemist is not available to test the cargo tanks before entry for oxygen, flammable gas and toxic gas concentration. Therefore, the Chief Mate and other officers are trained to perform tank testing, and the vessel carries its own supply of oxygen, combustible gas and toxic gas measuring instruments. Before the tank entry took place, the Chief Mate reviewed the preliminary version of the Safe Work Practice, and agreed to perform the tank testing in accord with the Work Practice. The vessel does not use a tank entry permit system. The entry permit was also reviewed with the Chief Mate, and it was filled in by a SwRI project team member.

The Safe Work Practice (see Section E.4) calls for the officer in charge of the tank entry operation to test the tank atmosphere for oxygen, combustible gas, and toxic vapor concentration (if the last cargo was a Subchapter O chemical, and toxic by vapor inhalation). The Work Practice also requires the officer in charge to wear an SCBA if he must enter the cargo tank to make the oxygen and toxic gas concentration measurements.

Two deviations from the Safe Work Practice occurred, (1) the Chief Mate did not use an SCBA or a chemical protective suit when he first entered the tank to test for oxygen, and (2) he did not station a crewman with emergency rescue equipment to watch while he was in the tank.

The Chief Mate explained that he had tested this tank a few days before when it was washed, gas freed, and manually cleaned. He said that he had worn an SCBA and a chemical protective suit on that occasion.

For the field test inspection, the Chief Mate began testing the tank for oxygen and combustible gas from the deck. The O_2/CGI instrument that he used has a long sample line that he lowered into the tank from the deck. This allowed gas samples to be taken down to the level of the first landing without entering the tank. He verified that the oxygen and combustible gas concentrations were acceptable, then entered the tank with the O_2/CGI sensor and continued to test the tank gas atmosphere at lower and lower levels until he reached the bottom of the tank.

Although methyl iso-butyl ketone is a Subchapter D chemical, the Chief Mate was asked to test for toxic vapor concentration during tank entry. He agreed to do so, but then found that the vessel's supply of toxic vapor detector tubes for this chemical was depleted. He said that a test for toxic vapor is carried out routinely for cargo tank entries. The final version of the Safe Work Practice in Section E.4 calls for toxic vapor testing only for Subchapter O and D chemicals that are toxic by vapor inhalation.

The tank entry permit system for assuring safe tank entry was discussed with the Chief Mate. He said that all of the check list items on the permit are good and that they represent a tank entry procedure. However, he said that so many tank entries are performed routinely on his vessel, that the effort involved in filling out the form and filing it away would be too time consuming. He did agree that an entry permit with a checklist of safety items would be very useful for training crewmembers to observe safe tank entry procedures.

The Safe Work Practice for tank top-off during open loading requires the crewman who gauges the tank to wear gloves, an air purifying respirator for Subchapter O chemicals, goggles or a full facepiece respirator if the chemical vapor is irritating to the eyes, and chemical protective clothing if the vapor is irritating to the skin.

During the field test observation, three Subchapter O chemicals were open loaded. The vessel did have a closed tank gauging system for each cargo tank, but they were not used, and ullage readings were taken manually using a tape. The vessel also had mast riser vents for each cargo tank. These vents were used only during the loading of ethylenediamine mixture. During tank top-off, the cargo tank gas atmosphere was vented to the air through open ullage hatches with flame screen.

The field test evaluation of the Safe Work Practice for tank top-off during open loading went very smoothly. The crewmen who gauged cargo tanks during loading and top-off wore full facepiece gas masks and gloves. The gas masks contained nose cups to prevent fogging of the eyepiece. The Mate on watch also wore a full facepiece gas mask respirator whenever he approached the cargo tank vents, or stood in the vapor plume. During the loading of ethylenediamine mixture both the watchman and the Mate on watch wore chemical protective clothing to prevent skin irritation from the chemical vapor.

Only one problem was experienced with the protective equipment. During top-off the vapor produced by the ethylenediamine mixture collected on the eyepiece of the respirator worn by the watchman. This obscured his vision, and made it difficult to gauge the tank.

V. CONCLUSIONS AND RECOMMENDATIONS

The key elements to developing an environmental monitoring plan for promoting MHCW work place safety are:

(1) determine which jobs or work activities may expose the worker to potential hazards,

(2) obtain information about the hazard potential and methods of protection for the chemicals encountered during work activities,

(3) determine how these jobs can be accomplished safely,

(4) provide the equipment and instrumentation necessary for safe performance of the job,

(5) train MHCW personnel to perform the job safely, and to use and maintain the necessary equipment and instrumentation, and

(6) enforce the safe performance of the job.

Items (1), (2), and (3) are necessary steps that lead to the development of Safe Work Practices for the jobs that involve potential exposure to hazardous materials. Items (4) and (5) involve implementing special procedures, operational equipment, instruments, and personal protective equipment as specified in the Safe Work Practice to eliminate potential exposures. Item (6) requires the support and supervision of management to ensure that the Safe Work Practice is followed and that potentially dangerous exposures to hazardous materials are eliminated.

V.1 Safe Work Practices

For companies that are involved in the marine transport of potentially hazardous chemicals, it is recommended that items (1), (2), and (3) listed above be carried out as the basis for developing a set of Safe Work Practices that cover their operations and employees.

A Safe Work Practice is a written document that outlines a method for performing a specific work activity without exposing the worker to hazardous materials at concentrations that exceed the TLV level. The developoment of a Safe Work Practice should involve the observation of how a job or operation is currently performed, and consideration of how the job could be performed more safely. It should list,

- each of the actual work activities that is performed during the operation,
- the potential hazard associated with each activity,
- safety instructions to be followed during each activity.

The Safe Work Practice should include specific instructions for the worker to follow concerning the use of instrumentation, and protective equipment, as the job is performed. For the Safe Work Practice to be effective in eliminating worker exposure

to hazardous materials, all work must be performed in accordance with the Safe Work Practice.

The Safe Work Practice should be used during the training of new employees, and in retraining current employees for new jobs. Periodic review of the Safe Work Practices with employees during safety meetings is also necessary to enforce their use. All Safe Work Practices should be reviewed annually. If conditions have changed, the Safe Work Practice should be revised accordingly.

Safe Work Practices for seven common MHCW scenarios have been developed as part of the Task II activity and are included in Appendices C, D, and E. Examples are also included in Section IV.3. These examples can be used by other organizations as a guide to the development of Safe Work Practices for their own operations and employees.

V.2 Instrumentation

Some of the MHCW job scenarios involve operations that are carried out inside enclosed spaces such as cargo tanks or pump rooms. It may be hazardous to work inside these spaces if the air in the space is oxygen deficient, or if the air is contaminated with liquid or vapor residue from hazardous chemicals. To determine if workers can do their jobs safely in enclosed spaces, three types of instruments are needed. These are instruments for measuring (1) oxygen concentration, (2) concentration of flammable or explosive gases or vapors, and (3) concentration of toxic gases or vapors.

As part of the Task II work activity, information was obtained from manufacturers and suppliers about the various types of instruments that are now available for measuring oxygen, combustible gas and toxic gas/vapor concentration. This information is presented in Volume II of the Task II Interim Report.

Both single function and dual function oxygen and combustible gas instruments are available. A single combustible gas instrument can be used to measure concentration in the combustible range for several different chemicals. However, the instrument reading may be different for different chemicals at the same concentration. To correct the indicated readings to a true value of concentration, the instrument manufacturer provides a set of response factors for several different chemicals.

Several instruments are also available for measuring the concentration of toxic gases or vapors in air. These instruments may respond to many different gases. They can be calibrated (or a response factor obtained) to measure the vapor concentration in air of any one of the chemicals to which they respond. To demonstrate the performance of a selected set of toxic vapor instruments under simulated use conditions, a set of laboratory tests was performed. The results of these tests are also reported in Volume II of the Task II Interim Report.

However, if the air contains a mixture of different vapors, the instrument may respond to all of them. An accurate measurement of concentration for any specific gas may be possible only when the other interfering gases are present in much lower concentrations.

If multiple gases or vapors are present in the air, an instrument is needed that can separate the different vapors and select the right one for measurement. Colorimetric toxic vapor detection tubes for certain chemicals are provided with filter

sections that trap and remove interfering gases. Other instruments use gas chromatography or vapor absorption principles to separate out the different gaseous constituents.

While many different types of instruments are currently available for O_2, combustible gas and toxic gas concentration measurement, not all lend themselves well to field use in marine environments. The types of instruments that are needed should be, (1) intrinsically safe, (2) portable and light weight, (3) easy to set up, calibrate, maintain, and operate, (4) inexpensive, (5) rugged, and (6) accurate.

For toxic gas concentration measurements, colorimetric detector tubes satisfy the criteria listed above and are available for many different chemicals. Unfortunately, there are some chemicals currently transported by water for which an instrument suitable for field use is not available for the measurement of concentration in the toxicity hazard range. If a chemistry laboratory with the proper analytical equipment is available, then a gas sample can be taken and analyzed. Laboratory analysis often introduces a delay of several hours or more before results are available.

V.3 Chemical Hazard Information

There are several sources of information available to the public on the properties of hazardous chemicals. The U.S. Coast Guard published the Chemical Hazards Response Information System, also known at CHRIS. CHRIS consists of four manuals,

- Manual 1, COMDTINST M16465.11 "A Condensed Guide to Chemical Hazards"
- Manual 2, COMDTINST M16465.12 "Hazardous Cemical Data"
- Manual 3, COMDTINST M16465.13 "Hazard Assessment Handbook"
- Manual 4, COMDTINST M16465.14 "Response Methods Handbook"

Manual 2 lists the specific chemical, physical and biological data for about 1000 chemicals that are needed for the other components of CHRIS. These manuals are available from the Government Printing Office.

The Coast Guard also publishes COMDTINST M16616.6, the Chemical Data Guide for Bulk Shipment by Water, 6th edition, which contains data on over 300 chemical cargos that are transported by water. Much of the data contained in the guide comes from CG-4355 forms (Characteristics of Liquid Chemicals Proposed for Bulk Water Movement) submitted to the Coast Guard before the cargo is classified for carriage. The Chemical Data Guide is also available from the Government Printing Office.

Companies that manufacture chemical materials provide Material Safety Data sheets on their commercial products. These data sheets include information on ingredients, physical properties, fire and explosion hazards, health hazards, chemical reactivity, spill or leak safety procedures, special protective equipment, storage and labeling requirements, toxicity data and other miscellaneous notes and data.

The ACGIH publishes a list of Threshold Limit Values (TLVs) for chemical substances and physical agents in the work environment. This list is reviewed and updated yearly by the ACGIH, and the TLVs are used as recommended upper limit values for chemical vapor concentration in the work place.

During cargo transfer operations in marine docks and terminals, a Cargo Information Card must be displayed to warn both dockmen and tankermen of potential hazards associated with the chemical being transferred. This card includes basic information about fire and exposure hazards, and provides instructions to be followed in case of an accidental spill, leak, fire or exposure.

Generally, it is hard to find a complete list of chemical hazard information for all of the Subchapter D and O chemicals in one place. As part of the Task III work activity, a complete compilation of health hazard information was prepared. This compilation appears in Volume II of the Task III final report. A subset of this information was prepared for use in Task II and appears in Appendix A of this report. This subset lists the chemical name, CHRIS code, TLV values, vapor pressure, and the availability of toxic vapor detection tubes for each of the Subchapter O and D chemicals.

Unfortunately, the information currently available is either incomplete, or deficient in two respects.

- o Some potentially hazardous (toxic) chemicals shipped in bulk by water do not have a Threshold Limit Value (TLV) adopted by the ACGIH. Many of these chemicals also do not have a permissible exposure limit value assigned by the manufacturer or the company that submits the CG-4355 form. Thus, without an accepted exposure limit value, it is not possible to determine whether it is safe to enter a space containing the vapor of that particular cargo without inhalation protective equipment.

- o The Cargo Information Cards displayed during cargo transfer operations warn MHCW personnel of potential exposure hazards, and how to treat an exposure. But the Cards do not indicate the type of protective equipment recommended to <u>prevent</u> exposure.

To fill these gaps it is recommended that:

(1) the Coast Guard require that companies filing new CG-4355 forms provide either an ACGIH TLV or a permissible exposure value that they recommend for use as an exposure limit;

(2) the Coast Guard request that the ACGIH consider the potentially toxic Subchapter O and D chemicals that do not have TLV values, and recommend TLV values for adoption;

(3) the Coast Guard request that Cargo Information Cards be revised to include information about proper protective equipment to be worn during cargo transfer operations such as hose connect/disconnect and open loading.

V.4 Protective Equipment

Protective equipment is often provided as the last level of protection following provision of engineering control and administrative control measures designed to eliminate potential exposures. In many cases it is possible to avoid the need to outfit tankermen and crewmen with respirators and protective clothing by the proper use of engineering controls such as cargo tank washing and ventilation systems, and mast riser vents or vapor return systems to dispose of cargo vapors during loading. For Coast Guard boarding parties and inspection teams, administrative controls such as requiring tank certification by a Marine Chemist before tank entry, and by temporarily

halting open loading operations during inspections, are effective methods for eliminating potential exposures.

However, engineering and administrative control measures can fail on occasion, and it is necessary to fully evaluate the need for protective equipment in this event. One example is the problem of maintaining closed tank gauging systems in working order on tankerships. If the gauging system cannot be relied upon to give accurate indications of liquid level, then the tank is usually open loaded for Subchapter O chemicals. The mast riser vent on the vessel is ineffective when the tank ullage hatch is open. Therefore, the crewman in charge of tank gauging needs to use respiratory protection, and possibly eye protection and protective clothing as well during tank top-off.

Proper protective equipment is commercially available for the work activities in which protective equipment is required. However, the level of protection now used for the same operation appears to vary widely throghout the marine transportation industry. One company that operates marine terminals has defined requirements for respiratory protection and protective clothing to be worn during cargo transfer operations in its facility. These requirements are applied not only to dock personnel, but also to barge tankermen and crewmen on tank vessels.

Other companies that operate loading docks and marine terminals generally do not enforce their own requirements for protective equipment on the barge tankermen or ship crewmen who take part in cargo transfer operations at their facilities. If these companies would require protective equipment equivalent to that worn by their own employees, it would make the use of protective equipment more uniform throughout the marine transportation industry.

V.5 Training

The level of prior training of MHCW personnel in chemical hazard recognition and control varies greatly. In response to new IMO requirements, the safety officers of chemical tankerships are now required to attend a course on tankership safety. The Chief Mate on the vessel that took part in the field test of Safe Work Practices (see Appendix E) had attended such a course, taught at the Southampton School of Nautical Studies in Southampton, England, and the safety officer was scheduled to attend the same course in the next 6 months. This course is also presented at the Maine Maritime Academy in the United States.

Several of the Coast Guard MIO marine inspectors who participated in the Safe Work Practice field test (see Appendix D) have attended a course on hazardous chemicals taught by Coast Guard instructors. However, none of the COTP warrant officers and trainees who took part in the field test had attended this course.

None of the barge tankermen who participated in the Safe Work Practice field test (see Appendix C) have had any formal training in chemical hazards. These workers are involved in the transfer of both Subchapter O and D chemicals routinely. They are generally aware that inhalation and skin exposure to certain chemicals can have either immediate or long term effects on their health. They may have read or heard that exposure to benzene is suspected of causing cancer. However, they lack detailed information about which chemicals are hazardous, and how they should protect themselves from exposure.

Many tankermen are dependent upon the marine terminals and loading dock for chemical hazard information. A pre-transfer conference is held between the dock and the tankermen to discuss how the transfer will be carried out. However, the only chemical hazard information given to the tankermen is that contained in the Cargo Information Card. The card may state that workers involved in cargo transfer should be properly protected, but offers no advice on what type of protection (gloves, respirator, goggles) is needed.

Adequate training in chemical hazard recognition and control is needed by all MHCW personnel who are exposed to hazardous chemicals. MHCW personnel should be trained to:

- recognize which work activities may expose them to hazardous chemicals in either liquid or vapor form,
- recognize which chemicals are potentially hazardous,
- health symptoms resulting from chemical exposure,
- how to protect themselves from chemical exposure in their work,
- how to use and maintain protective equipment, and
- emergency treatment for accidental exposure, including the use of eye-wash and safety showers, and first aid.

APPENDIX A

INFORMATION ON CHEMICALS SHIPPED IN BULK

REGULATED UNDER 46CFR SUBCHAPTERS D AND O

AS OF MAY 1983

A.1 Background

This section contains a listing of key environmental monitoring data for a set of 675 chemicals and liquified gases. This set comprises a complete list as of May 1983 of the chemicals and gases for which bulk shipment by water is authorized by the Coast Guard and regulated under 46CFR Subchapters D and O. This listing of information was condensed from a complete summary of health hazard and environmental monitoring data for all Subchapter O and D chemicals and gases prepared as part of the Task III Medical Monitoring activity. The complete summary list appears as Volume II of the Task III Interim Report on SwRI Project 06-7223.

The set of chemicals covered under Subchapter O regulations contains most of the chemicals that have a high health hazard potential. The National Academy of Sciences (NAS) reviewed the health hazard potential of many of the chemicals shipped in bulk by water and ranked them on a scale of 0 (not hazardous) to 4 (severely hazardous). The NAS evaluation considered health hazards in three categories: (1) irritation from chemical vapors; (2) irritation from chemicals in liquid or solid form; and (3) chemical poisoning. The results are published in NAS publication 1465 (1970 revision). Most of the Subchapter O chemicals have NAS health hazard ratings of 2, 3, or 4 in at least one health hazard category. Those with lower hazard ratings may form hazardous by-products as the result of fire, thermal decomposition, or chemical reaction.

The chemicals regulated under Subchapter D are primarily flammability hazards more than they are toxic, corrosive or reactive hazards. However, some of the Subchapter D chemicals (such as methanol and gasoline) do have ACGIH threshold limit values, and their vapor pressures are sufficiently high that their health hazard potential should not be discounted.

The list of Subchapter O and D chemicals in Section A.3 should be reviewed by companies and organizations that are involved in the MHCW industry. If MHCW personnel are potentially exposed to any of the chemicals listed in Section A.3 during operations, the name of the chemical should be recorded on a separate list specific to their operations.

An industrial hygiene (I.H.) specialist should be sought to evaluate the health hazard potential of the chemicals noted on the operation specific list. The I.H. specialist will also assist the company or organization in developing an industrial hygiene program to prevent exposure of MHCW personnel to those chemicals that pose a health hazard.

A.2 Explanation of Column Headings

The following table of environmental monitoring data lists information for 675 chemicals under 12 columns, The column headings are explained below.

- Chemical Name - This is the name that appears in the CHRIS (Chemical Hazard Response Information System) list of chemicals. Synonyms for many of these chemical names may be found either in CHRIS or in the Chemical Data Guide for Bulk Shipment by Water published by the U. S. Coast Guard.

- CHRIS Code - This is a three letter designation assigned to every chemical in the CHRIS list of chemicals. It is convenient to use the CHRIS code for a chemical of interest when looking up physical property data or other information contained in CHRIS.

- CFR - This column contains either an O or a D. These letters signify that the chemical is regulated under either 46CFR Subchapter O or D. Certain liquified gases that are regulated under 46CFR 154 are indicated as Subchapter O chemicals.

- Other Route - This column identifies chemicals that have another toxicologically important route of entry into the body in addition to vapor inhalation.

- TLV-TWA - The value of the time weighted average threshold limit value (TLV-TLV) adopted by the ACGIH for 1984-85 appears in this column. If a value is no given, the ACGIH has not adopted a value for that particular chemical. Units of measurement are ppm unless indicated otherwise.

- STEL - The value of the short term exposure threshold limit value (TLV-STEL) adopted by the ACGIH for 1984-85 appears in this column. If a value is not given, the ACGIH has not adopted a value for that particular chemical. Units of measurement are ppm unless indicated otherwise.

- IDLH - The value of concentration that is considered to be "Immediately Dangerous to Life or Health". This concentration represents a maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

- CS - This column gives the value of saturation concentration corresponding to the vapor pressure of the chemical in air at 20° C and 1 atmosphere. The saturation concentration is the maximum concentration of chemical vapor in air that can be achieved for an air/vapor mixture in thermodynamic equilibrium.

The next three columns present information about the availability of colorimetric toxic vapor detector tubes for measurement of vapor concentration in air. This information was drawn from the review of Environmental Monitoring Devices that appears in Volume II of the Task II Final Report. These columns are explained in the order that they appear in the data list.

- TLV DT - An entry in this column indicates that a toxic vapor tube is commercially available for measuring the vapor concentration in a concentration range that includes the TLV-TWA for this chemical.

- QUAN DT - An entry in this column indicates that a toxic vapor tube is commercially available for measuring the vapor concentration for this chemical. However, the range of measurement does not include the TLV-TWA.

- <u>QUAL DT</u> - An entry in this column indicates that a toxic vapor tube specifically designed to measure vapor concentration for this chemical is not available. However, the vapor concentration can be measured on another toxic vapor tube that is sensitive to this chemical. The range of measurement may or may not include the TLV-TWA (see Volume II of the Task II Final Report for more information).

These columns may contain an entry of D, G, or DG. An entry of D signifies that a detector tube manufactured by National Draeger is available. An entry of G signifies that a detector tube manufactured by Gastec is available. An entry of DG signifies that detector tubes are available from both Draeger and Gastec.

The last column on the information list contains a sequence number (SEQ NO.). This is a number that was assigned to the chemical during the Task III Medical Monitoring activity. This number should be used for looking up additional health hazard information in the complete list of chemicals that appears in Volume II of the Task III final report.

04-OCT-85

CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CS PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
ACETALDEHYDE	AAD	O		100	150	10000	9.9E5	DG	DG		001
ACETIC ACID	AAC	O		10	15	1000	1.5E4	DG	DG		002
ACETIC ANHYDRIDE	ACA	O		C5		1000	5.3E3	G	DG		003
ACETONE	ACT	D		750	1000	20000	2.4E5	D	DG		004
ACETONE CYANOHYDRIN	ACY	O	SKIN	0.25			1.1E3		G		005
ACETONITRILE	ATN	O	SKIN	40	60	4000	9.6E4				006
ACETOPHENONE	ACP	D		1			1.3E3		D		007
ACETYL TRIBUTYL CITRATE		D									008
ACRYLAMIDE (50% OR LESS)	AAM	O	SKIN	0.3 MG/M3	0.6 MG/M3						009
ACRYLIC ACID	ACR	O		10			4.1E3				010
ACRYLONITRILE	ACN	O	SKIN	2		4000	1.1E5	DG	DG		011
ADIPONITRILE	ADN	O		50							012
ALCOHOLS (MIXED)		D								D	013
ALKENYL SUCCINIC ACID		D									014
ALKENYLSUCCINIC ANHYDRIDE		D									015
ALKYLBENZENESULFONIC ACIDS	ABS	O		1 MG/M3							016
N-ALKYL PHTHALATES		D									017
ALKYL SUCCINNATE FORMALDEHYDE HYDROXY AM		D									018
ALLYL ALCOHOL	ALA	O	SKIN	2	4	150	2.2E4		D		019
ALLYL CHLORIDE	ALC	O		1	2	300	3.9E5				020
2-(2-AMINOETHOXY)ETHANOL	AEX	O							D		021
AMINOETHYLETHANOLAMINE	AEE	O									022
N-AMINOETHYLPIPERAZINE	AEP	O							D		023
AMMONIA, ANHYDROUS	AMA	O		25	35	500	1.0E6	DG	DG		024
AMMONIUM HYDROXIDE, 28 PERCENT AQ.	AMH	O		200		500			D		025
N-AMYL ACETATE	AML	D		100	150	4000	5.3E3	G	DG		026
N-AMYL ALCOHOL	AAN	D		100			3.7E3			D	027
AMYLENE		D					5.3E5			D	028
N-AMYL METHYL KETONE	AMK	D		50	100		3.4E3				029
AMYL TALLATE		D									030
ANILINE	ANL	O	SKIN	2	5	100	7.9E2	DG	DG		031
ASPHALT	ASP	D		5 MG/M3	10 MG/M3						036
ASPHALT BLENDING STOCKS: ROOFERS FLUX	ARF	D		5 MG/M3	10 MG/M3						037
ASPHALT BLENDING STOCKS: STRAIGHT RUN RE	ASR	D		5 MG/M3	10 MG/M3						038
BEHENYL ALCOHOL		D									039
BENZENE	BNZ	O		10	25	2000	9.9E4	DG	DG		040
BENZENE HYDROCARBON MIX (> OR = 10% BEN)	BHB	O		10	25			D	D		041
BENZENE HYDROCARBON MIX (WITH ACETYLENE)	BHA	O		10	25				D		042
BENZENESULFONYL CHLORIDE	BSC	O					5.3E1				043
BENZENE, TOLUENE, XYLENE MIXTURE	BTX	O		10	25	2000	9.9E4		D		044
BENZYL ALCOHOL	BAL	D									045
BENZYL CHLORIDE	BCL	O		1		10	1.2E4	G	DG		046
BICYCLIC TERPENEL POLYAMINE AMIDE SALT		D									048
BISPHENOL A DIGLYCIDYL ETHER	BDE	D									049
BUTADIENE (1,3 BUTADIENE)	BDI	O		10	15	20000	1.0E6		DG		050
BUTADIENE, BUTYLENE MIX WITH ACETYLENES	BBM	O		10	15	20000			D		051
BUTANE	BUT	O		800			1.0E6		DG		052
N-BUTYL ACETATE	BCN	D		150	200	10000	1.1E4	G	DG		053
SEC-BUTYL ACETATE	BTA	D		200	250	10000	2.7E4			D	054
ISO-BUTYL ACRYLATE	BAI	O		10			1.4E4		D		055
BUTYL ACRYLATE (INH) (ISO, N, AND MIXES)	BAR	O		10					D		056
N-BUTYL ACRYLATE	BTC	O		10			4.2E3		D		057
N-BUTYL ALCOHOL	BAN	D	SKIN	C50		8000	1.2E4	G	DG		058
SEC-BUTYL ALCOHOL	BAS	D		100	150	10000	4.1E4	G	DG		059
TERT-BUTYL ALCOHOL	BAT	D		100	150	8000	4.0E4	G	G		060

04-OCT-85

CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CB PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
BUTYLAMINE (ALL ISOMERS)	BTY	O	SKIN	C5		2000	2.9E5		D		061
N-BUTYLAMINE	BAM	O	SKIN	C5			1.1E5	Q	DQ		062
SEC-BUTYLAMINE	BTL	O	SKIN	C5			1.8E5		D		063
TERT-BUTYLAMINE	BUA	O	SKIN	C5			4.5E5		D		064
BUTYLBENZYL PHTHALATE	BPH	D					2.1E2				065
BUTYLENE	BTN	O					1.0E6		D		066
BUTYLENE GLYCOL		D					7.8E1				067
1,2-BUTYLENE OXIDE	BTO	O		400			2.7E5				068
BUTYLENE POLYGLYCOL		D									069
N-BUTYL ETHER	BTE	O							D		070
BUTYL HEPTYL KETONE		D									071
ISO-BUTYL METHACRYLATE	BMI	O								D	072
N-BUTYL METHACRYLATE	BMN	O					4.6E3				073
BUTYL METHYL KETONE		D		5					D		074
BUTYL STEARATE		D									075
BUTYL TOLUENE (P-TERT)		D		10 (P-T)	20 (P-T)	1000			D		076
ISO-BUTYRALDEHYDE	BAD	O					1.5E5			D	077
BUTYRALDEHYDE (ISO, N, AND MIXTURES)	BAE	O								D	078
N-BUTYRALDEHYDE	BTR	O					1.2E5			D	079
GAMMA-BUTYROLACTONE	BLA	D									080
CALCIUM ALKYLPHENATE		D									082
CALCIUM ALKYL SALICYLATE	CAK	D									083
CALCIUM AMINO NONYL PHENOLATE		D									084
CALCIUM CARBOXYLATE		D									085
CAMPHOR	CPO	O		2	3						086
CAMPHOR (OIL)	CPO	O		2	3	32	2.4E2				087
CAPROLACTAM (SOLUTION)	CLS	D		5	10		1.3E4				088
CARBOLIC OIL (PHENOL)	CBO	O		5	10	100	6.6E2			D	089
CARBON BLACK BASE		D		3.5 MG/M3	7.0 MG/M3						090
CARBON DISULFIDE	CBB	O	SKIN	10		500	3.9E5	DQ	DQ		091
CARBON TETRACHLORIDE	CBT	O	SKIN	5	20	300	1.2E5	DQ	DQ		093
CAUSTIC POTASH SOLUTION	CPS	O	SKIN	C2 MG/M3							094
CAUSTIC SODA SOLUTION	CSS	O	SKIN	C2 MG/M3			2.2E3				095
CETYL ALCOHOL		D									096
CETYL-EICOSYL METHACRYLATE	CEM	O									097
CETYL STEARYL ALCOHOL		D									098
CHEMICAL WASTES (CHLOR HCARBONS & CAUST)	CWC	O	SKIN	10						D	099
CHLORINE	CLX	O		1	3	25	1.0E6	DQ	DQ		100
CHLOROACETIC ACID SOLUTION (80% OR LESS)	CHM	O							D		101
CHLOROBENZENE	CRB	O		75		2400	1.2E4	DQ	DQ		102
CHLOROFORM	CRF	O		10	50	1000	2.1E5	DQ	DQ		103
CHLOROHYDRINS (CRUDE)	CHD	O		5		25	6.7E3				104
CHLOROPRENE	CRP	O	SKIN	25		400	2.4E5	D	D		105
2-CHLOROPROPIONIC ACID	CLA	O		2							106
3-CHLOROPROPIONIC ACID	CLP	O									107
2- AND 3-CHLOROPROPIONIC ACID MIXTURE	CPM	O		2 (2-)							108
CHLOROSULFONIC ACID	CSA	O		1					D		109
CHLOROTOLUENE (O, M, P, AND MIXTURES)	CHI	O	SKIN (O-)	50 (O-)	75 (O-)						110
M-CHLOROTOLUENE	CTM	O									111
O-CHLOROTOLUENE	CTO	O	SKIN	50	75						112
P-CHLOROTOLUENE	CRN	O		50							113
CLEANING SPIRIT (UNLEADED)		D									115
CREOSOTE	CCW	O						D	D		116
M-CRESOL	CRL	O	SKIN	5		250	2.0E2	DQ	DQ		117
O-CRESOL	CSL	O	SKIN	5		250	3.3E2	DQ	DQ		118

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P-CRESOL	CSO	O	SKIN	5		250	1.4E2	DQ	DQ		119
CRESOLS	CRS	O	SKIN	5		250	6.8E2	DQ	DQ		120
CRESYLATE SPENT CAUSTIC	CSC	O		5		250					121
CROTONALDEHYDE	CTA	O		2	6	400	3.9E4		D		122
CUMENE	CUM	D	SKIN	50	75	8000	2.0E4	Q	DQ		123
CYCLOHEXANE	CHX	D		300	375	10000	1.3E5	DQ	DQ		124
CYCLOHEXANOL	CHN	D		50		3500	1.3E3				125
CYCLOHEXANONE	CCH	O		25	100	5000	2.6E3	Q	Q		126
CYCLOHEXYLAMINE	CHA	O	SKIN	10				Q	DQ		127
CYCLOPENTADIENE POLYMERS		D		75	150	2000					128
P-CYMENE	CMP	D									129
N-DECALDEHYDE	DAL	D					2.9E2				130
DECANE	DCC	D									131
1-DECENE	DCE	D									132
DECYL ACRYLATE (ISO, N, AND MIXTURES)	DAT	O					1.3E1				133
N-DECYL ACRYLATE	DAR	O									134
N-DECYL ALCOHOL	DAN	D									135
N-DECYLBENZENE	DBZ	D									136
DETERGENT ALKYLATE		D					1.3E1				137
DIACETONE ALCOHOL	DAA	D		50	75	2100	1.3E3		D		138
DIAMMONIUM SALT OF ZINC EDTA (SOLUTION)	DSZ	O									139
DI-N-BUTYLAMINE	DBA	O					2.6E3				140
DIBUTYL CARBINOL		D					3.9E2				141
DIBUTYL PHTHALATE	DPA	D		5 MG/M3	10 MG/M3						142
M-DICHLOROBENZENE	DBM	O				1500			D		143
O-DICHLOROBENZENE	DBO	O		C50		1700	1.3E3	Q	DQ		144
P-DICHLOROBENZENE	DBP	O		75	110	1000			D		145
DICHLORODIFLUOROMETHANE	DCF	O		1000	1250	50000	1.0E6				146
1,1-DICHLOROETHANE	DCH	O		200	250	4000	2.4E5		Q		147
2,2'-DICHLOROETHYL ETHER	DEE	O	SKIN	5	10	250	5.3E2				148
DICHLOROISOPROPYL ETHER	DCI	O									149
DICHLOROMETHANE (METHYLENE CHLORIDE)	DCM	O		100	500	2000	4.6E5		D		150
DICHLOROMONOFLUOROMETHANE	DFM	O		10			1.0E6				151
2,4-DICHLOROPHENOL	DCP	O							D		152
1,1-DICHLOROPROPANE	DPB	O							D		153
1,2-DICHLOROPROPANE	DPP	O		75	110		5.3E4	Q	DQ		154
1,3-DICHLOROPROPANE	DPC	O									155
1,3-DICHLOROPROPENE	DPU	O	SKIN	1	10		1.4E5				156
DICHLOROPROPENE (1,1- 1,2- 1,3- AND MIX)	DPS	O	SKIN	1	10						157
DICHLOROPROPENE, DICHLOROPROPANE MIXTURE)	DMX	O	SKIN	1	10						158
2,2-DICHLOROPROPIONIC ACID	DCN	O		1							159
DICHLOROTETRAFLUOROETHANE	DTE	O		1000	1250	50000	1.0E6				160
DICYCLOPENTADIENE	DPT	D		5		50	2.0E3		D		161
DIETHANOLAMINE	DEA	O		3			1.0E2			D	162
DIETHYLAMINE	DEN	O		10	25	2000	2.6E5	Q	DQ		163
DIETHYLBENZENE	DEB	D					1.3E3		DQ		164
DIETHYLENE GLYCOL	DEG	D		100							165
DIETHYLENE GLYCOL DIETHYL ETHER		D									166
DIETHYLENEGLYCOL MONOBUTYL ETHER ACETATE	DEM	D									167
DIETHYLENE GLYCOL MONOBUTYL ETHER	DME	D									168
DIETHYLENEGLYCOL MONOETHYL ETHER	DGE	D		5							169
DIETHYLENE GLYCOL MONOETHYL ETHER ACETAT		D		5							170
DIETHYLENEGLYCOL MONOMETHYL ETHER	DGM	D		5			2.6E2				171
DIETHYLENE GLYCOL MONOMETHYL ETHER ACET		D		5					D		172
DIETHYLENE GLYCOL MONOPHENYL ETHER		D									173

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DIETHYLENETRIAMINE	DET	O	SKIN	1					DQ		174
DIETHYLETHANOLAMINE	DAE	O		10			1.3E3				175
DI-(2-ETHYLHEXYL)PHOSPHORIC ACID	DEP	O									176
DI(ETHYLHEXYL)PHTHALATE		D		5 MG/M3							177
DIETHYL PHTHALATE	DPH	D		5 MG/M3	10 MG/M3						178
DIETHYL SULFATE	DSU	O									179
DIHEPTYL PHTHALATE	DHP	D									180
DIHEXYL PHTHALATE		D									181
DIISOBUTYLAMINE	DBU	O									182
DIISOBUTYLCARBINOL	DBC	D					3.9E2				183
DIISOBUTYLENE	DBL	D					8.8E4				184
DIISOBUTYL KETONE	DIK	D		25		2000	1.3E3				185
DIISOBUTYL PHTHALATE	DIT	D									186
DIISODECYL PHTHALATE	DID	D									187
DIISONONYL PHTHALATE	DIN	D									188
DIISOOCTYL PHTHALATE	DIO	D									189
DIISOPROPANOLAMINE	DIP	O									190
DIISOPROPYLAMINE	DIA	O	SKIN	5		1000	9.2E4	Q	DQ		191
DIISOPROPYL BENZENE		D									192
DIMETHYLACETAMIDE	DAC	O	SKIN	10	15		1.9E3	DQ	DQ		193
DIMETHYLAMINE	DMA	O		10		2000	1.0E6	Q	DQ		194
DIMETHYLAMINE SOLUTION (45% OR LESS)	DMG	O		10		2000			D		195
DIMETHYLAMINE SOLUTION (>45% AND <=55%)	DMY	O		10		2000	4.2E5				196
DIMETHYLAMINE SOLUTION (55% AND <65%)	DMC	O		10		2000					197
DIMETHYL AMMONIUM-2,4-DICHLOROPHENOXYACE	DDA	O									198
N,N-DIMETHYLCYCLOHEXYLAMINE	DXN	O					3.6E3				199
DIMETHYLETHANOLAMINE	DMB	O					5.5E3		D		200
DIMETHYLFORMAMIDE	DMF	O	SKIN	10	20	3500	3.6E3	Q	DQ		201
DIMETHYL PHTHALATE	DTL	D		5 MG/M3	10 MG/M3	9300 MG/M3	1.3E3				202
2,2-DIMETHYLPROPANE-1,3-DIOL		D							D		203
DINONYL PHTHALATE		D									204
DI(OCTYLPHENYL)AMINE		D									205
DIOCTYL PHTHALATE	DOP	D		5 MG/M3			1.3E1				206
1,4-DIOXANE	DOX	O	SKIN	25	100	200	3.6E4		DQ		207
DIPENTENE	DPN	D								D	208
DIPHENYL	DIL	D		0.2	0.6	50					209
DIPHENYL DIPHENYL OXIDE	DDO	D		0.5							210
DIPHENYL ETHER	DPE	D		1			2.6E1				211
DIPHENYLMETHANE DIISOCYANATE	DPM	O		C0.02		20					212
DI-N-PROPYLAMINE	DNA	O					3.9E4				213
DIPROPYLENE GLYCOL	DPG	D								D	214
DIPROPYLENE GLYCOL MONOMETHYL ETHER		D		100	150		3.9E2			D	215
DISTILLATES: FLASHED FEED STOCKS	DFF	D									216
DISTILLATES: STRAIGHT RUN	DSR	D									217
DIUNDECYL PHTHALATE	DUP	D									218
DODECANE		D					3.9E2				219
DODECANOL	DDN	D					1.3E3				220
DODECENE	DOD	D									221
1-DODECENE	DDC	D									222
DODECYLBENZENE	DDB	D					1.3E1				223
DODECYL DIPHENYL OXIDE DISULFONATE SOLN	DOS	O									224
DODECYLMETHACRYLATE	DDM	O									225
DODECYL PENTADECYL METHACRYLATE	DDP	O									226
DODECYL PHENOL		D							D		227
EPICHLOROHYDRIN	EPC	O	SKIN	2	5	100	1.6E4	Q	DQ		228

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EPOXYLATED LINEAR ALCOHOLS, C11-C15		D									229
ETHANE	ETH	O								D	230
2-ETHOXYETHANOL	EGE	D	SKIN	5		6000	5.0E3		Q	D	231
2-ETHOXYETHYL ACETATE		D	SKIN	5		2500	5.0E3		D		232
ETHOXYLATED DODECANOL	EOD	D									233
ETHOXYLATED PENTADECANOL	EOP	D									234
ETHOXYLATED TETRADECANOL	EOT	D									235
ETHOXYLATED TRIDECANOL	ETD	D									236
ETHOXYLATED UNDECANOL		D									237
ETHOXY TRIGLYCOL	ETG	D					1.3E1				238
ETHYL ACETATE	ETA	D		400		10000	1.3E5	DQ	DQ		239
ETHYL ACRYLATE	EAC	O	SKIN	5	25	2000	3.9E4		DQ		240
ETHYL ALCOHOL	EAL	D		1000			5.8E4	DQ	DQ		241
ETHYLAMINE	EAM	O		10		4000	1.0E6	Q	DQ		242
ETHYLAMINE (40% OR LESS)	EAO	O		10		4000					243
ETHYLAMINE (72% OR LESS)	EAN	O		10		4000			D		244
ETHYL AMYL KETONE		D		25		3000	2.6E3				245
ETHYLBENZENE	ETB	D		100	125	2000	2.0E4	DQ	DQ		246
ETHYL BUTANOL	EBT	D		100		1500	1.2E3		D		247
N-ETHYL-N-BUTYLAMINE	EBA	O									248
ETHYL CHLORIDE	ECL	O		1000	1250	20000	1.0E6	Q	Q		249
ETHYL CYCLOHEXANE	ECY	D									250
N-ETHYL CYCLOHEXYLAMINE	ECC	O		370 MG/M3							251
ETHYLENE	ETL	O							DQ		252
ETHYLENE CARBONATE		D									253
ETHYLENE CHLOROHYDRIN	ECH	O	SKIN	C1		10	8.9E3				254
ETHYLENE CYANOHYDRIN	ETC	O									255
ETHYLENEDIAMINE	EDA	O		10		2000	1.4E4	Q	DQ		256
ETHYLENE DIBROMIDE	EDB	O	SKIN	--		400	1.2E4		DQ		257
ETHYLENE DICHLORIDE	EDC	O		10	15	1000	1.3E5		DQ		258
ETHYLENE GLYCOL	EGL	D		C50			6.6E1		Q		259
ETHYLENE GLYCOL DIACETATE	EGY	D									260
ETHYLENE GLYCOL METHYL BUTYL ETHER		D									261
ETHYLENE GLYCOL MONOBUTYL ETHER	EGM	D	SKIN	25		700	1.0E3		DQ		262
ETHYLENE GLYCOL MONOBUTYL ETHER ACETATE	EMA	D							D		263
ETHYLENE GLYCOL MONOETHYL ETHER ACETATE	EGA	D	SKIN	5		2500	1.6E3		D		264
ETHYLENE GLYCOL MONOISOPROPYL ETHER		D		25							265
ETHYLENE GLYCOL MONOMETHYL ETHER	EME	D	SKIN	5			8.2E3		DQ		266
ETHYLENE GLYCOL MONOMETHYL ETHER ACETATE		D		5	35	2500	9.2E3		DQ		267
ETHYLENE GLYCOL PHENYL ETHER		D									268
ETHYLENE OXIDE	EOX	O		1		800	1.0E6	Q	DQ		269
ETHYLENE OXIDE, PROPYLENE OXIDE MIXTURE	EPM	O		1		1400			D		270
ETHYLENE - PROPYLENE COPOLYMERS		D									271
ETHYL ETHER	EET	O		400	500	19000	5.8E5	Q	DQ		272
ETHYLHEXALDEHYDE	EHA	D									273
ETHYLHEXANOIC ACID (ETHYL HEXOIC ACID)		D									274
2-ETHYL HEXANOL	EHX	D					4.7E2				275
2-ETHYLHEXYL ACRYLATE	EAI	O					1.3E2				276
2-ETHYL HEXYLAMINE	EHM	O									277
ETHYL HEXYL PHTHALATE		D									278
ETHYLHEXYL TALLATE	EHT	D									279
ETHYLIDENE NORBORNENE	ENB	O		C5			6.0E3				280
ETHYL METHACRYLATE	ETM	O					2.0E4				281
2-ETHYL-3-PROPYLACROLEIN	EPA	O					6.6E2				282
ETHYL TOLUENE	ETE	D									283

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FATTY ACID AMIDES		D									284
FERRIC CHLORIDE SOLUTIONS	FCS	O		1 MG/M3							285
FORMALDEHYDE SOLUTION	FMS	O		1	2	100	1.7E3	DQ	DQ		287
FORMAMIDE	FAM	D		20	30		1.3E2				288
FORMIC ACID	FMA	O		5		100	7.9E2	Q	DQ		289
FURFURAL	FFA	O	SKIN	2	10	250	2.0E3	Q	Q		290
FURFURYL ALCOHOL	FAL	D	SKIN	10	15	250	1.3E3				291
GAS OIL: CRACKED	GOC	D									292
GASOLINE: AUTOMOTIVE (4.23G PB/GAL)	GAT	D		300	500	10000	2.5E5	Q	DQ		293
GASOLINE: AVIATION (4.86G PB/GAL)	GAV	D		300	500	10000					294
GASOLINE BLENDING STOCKS: ALKYLATES	GAK	D		300	500	10000					295
GASOLINE BLENDING STOCKS: REFORMATES	GRF	D		300	500	10000					296
GASOLINE: CASINGHEAD	GCS	D		300	500	10000			D		297
GASOLINE: POLYMER	GPL	D		300	500	10000					298
GASOLINE: STRAIGHT RUN	GSR	D		300	500	10000			D		299
GLUTARALDEHYDE (50% OR LESS)	GTA	O		C0.2			2.2E4			D	300
GLYCERINE	GCR	D		10 MG/M3							301
GLYCERYL TRIACETATE		D									302
GLYCIDYL ESTER OF TERTIARY CARBOXYLIC AC		D									303
GLYCIDYL ESTER OF VERSATIC ACID		D									304
GLYCOLS, RESINS, AND SOLVENTS MIXTURE		D								D	305
GLYCOL TRIACETATE		D									306
GLYOXAL, 40% SOLUTION	GOS	D									307
GREASE		D									308
HEPTADECANE		D									309
HEPTANE	HPT	D		400	500	4250	1.5E4	G	DG		310
HEPTANOIC ACID	HEP	D									311
HEPTANOL	HTN	D							D		312
1-HEPTENE	HTE	D									313
HERBICIDE (C15-H22-NO2-CL)		D									314
HEXAETHYLENE GLYCOL		D									315
HEXAMETHYLENEDIAMINE	HMD	O									316
HEXAMETHYLENEDIAMINE SOLUTION	HMC	O									317
HEXAMETHYLENE GLYCOL		D									318
HEXAMETHYLENEIMINE	HMI	O					6.6E3				319
HEXANE	HXA	D		50		5000	1.2E5	Q	DG		320
HEXANOL	HXN	D					1.3E3		D		321
1-HEXENE	HXE	D									322
HEXYL ACETATE		D		50	300	4000	5.3E3		D		323
HEXYLENE GLYCOL	HXG	D		C25	C125	UA	6.6E1				324
HOG GREASE		D									325
HYDROCHLORIC ACID	HCL	O		C5		100	2.8E5	D	DG		326
HYDROCHLORIC ACID, SPENT (15% OR LESS)	HCS	O		C5		100			DG		327
HYDROFLUORIC ACID	HFA	O		3	6	100			G		328
HYDROGEN CHLORIDE	HDC	O		C5		100	1.0E6	DQ	DG		329
HYDROGEN FLUORIDE	HFX	O		3	6	20	1.0E6	DQ	DG		330
2-HYDROXYETHYL ACRYLATE	HAI	O									332
INDUSTRIAL WASTES (METHYL MERCAPTAN, ETC)	INW	O		0.5 (M-M)							333
ISOAMYL ACETATE	IAT	D		100	125	3000	5.3E3		D		334
ISOBUTYL ACETATE	IBA	D		150	187	7500	1.7E4	G	DG		335
ISOBUTYL ALCOHOL	IAL	D		50	75	8000	1.2E4		DG		336
ISOBUTYLAMINE	IAM	O					1.3E5		D		337
ISODECALDEHYDE	IDA	D					2.9E2				338
ISODECYL ACRYLATE	IAI	O					1.3E1				339
ISODECYL ALCOHOL	ISA	D									340

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ISOHEXANE	IHA	D					1.3E5		D		341
ISOOCTALDEHYDE	IOC	D									342
ISOPHORONE	IPH	D		C5		800	3.9E2				343
ISOPHORONE DIAMINE	IPI	O									344
ISOPHORONE DIISOCYANATE	IPD	O	SKIN	C0.01							345
ISOPRENE	IPR	O		1000			5.3E5				346
ISOPROPYL ACETATE	IAC	D		250	310	16000	5.7E4		DG		347
ISOPROPYL ALCOHOL	IPA	D		400	500	20000	4.3E4	DG	DG		348
ISOPROPYLAMINE	IPP	O		5	10	4000	6.1E5	G	DG		349
ISOPROPYLAMINE (90% OR LESS)	IPO	O		5	10	4000			D		350
ISOPROPYL ETHER	IPE	O		250	310	10000	1.7E5		D		351
ISOVALERALDEHYDE	IVA	O									352
JET FUEL: JP-1 (KEROSENE)	JPO	D		100 MG/M3					D		353
JET FUEL: JP-3	JPT	D									354
JET FUEL: JP-4	JPF	D							D		355
JET FUEL: JP-5 (KEROSENE, HEAVY)	JPV	D							D		356
KEROSENE	KRS	D		100 MG/M3			2.7E3		DG		357
LACTIC ACID	LTA	D									358
LARD		D									359
LATEX, LIQUID SYNTHETIC	LLS	D									360
LIQUIFIED NATURAL GAS (OR LPG)	LNG	O							D		363
MAGNESIUM NONYL PHENOL SULFIDE		D									364
MAGNESIUM SULFONATE		D									365
MALEIC ANHYDRIDE	MLA	O		0.25			0.1E0				366
MALEIC ANHYDRIDE COPOLYMER		D									367
2-MERCAPTOBENZOTHIAZOLE (SOLUTIONS)	MBT	D									369
MESITYL OXIDE	MSO	O		15	25	5000	1.1E4				371
METHACRYLIC ACID	MAD	O		20			1.3E3		D		372
METHANE	MTH	O							D		373
METHOXYTRIGLYCOL	MTG	D									374
METHYL ACETATE	MTT	D		200	250	10000	2.2E5		D		375
METHYL ACETOACETATE		D									376
METHYL ACETYLENE, PROPADIENE MIXTURE	MAP	O		1000	1250	20000	1.0E6				377
METHYLACRYLATE	MAM	O	SKIN	10		1000	9.0E4		DG		378
METHYL ALCOHOL	MAL	D	SKIN	200	250	25000	1.3E5	G	DG		379
METHYLAMINE SOLUTION (42% OR LESS)	MSZ	O		10		100	1.0E6	G	G		380
METHYL AMYL ACETATE	MAC	D		50			4.7E3				381
METHYL AMYL ALCOHOL(METHYLISOBUTYL CARB.	MAA	D	SKIN	25	40	2000	6.6E3				382
METHYL BROMIDE	MTB	O	SKIN	5	15	2000	1.0E6	D	DG		383
METHYL BUTANOL (ISOAMYL ALCOHOL)		D		100	125	8000					384
METHYL-T-BUTYL ETHER	MBE	D									385
METHYL CHLORIDE	MTC	O		50	100	1000	1.0E6		D		386
2-METHYL-6-ETHYL ANILINE	MEN	O	SKIN	260							387
METHYL ETHYL KETONE (2-BUTANONE)	MEK	D		200	300	3000	1.3E5	G	DG		388
2-METHYL-5-ETHYLPYRIDINE	MEP	O					1.2E3				389
METHYL FORMAL	MTF	D									390
METHYL FORMATE	MFM	O		100	150	5000	5.3E5				391
METHYL HEPTYL KETONE (ETHYL AMYL HEPTANO	MHK	D		25		3000					392
2-METHYL-2-HYDROXY-3-BUTYNE	MHB	O									393
METHYL ISOBUTYL CARBINOL	MIC	D	SKIN	25	40	2000	5.0E3				394
MEHTYL ISOBUTYL KETONE (HEXONE)	MIK	D		50	75	3000	1.3E4		DG		395
METHYL METHACRYLATE	MMM	O		100	125	4000	4.6E4	D	DG		396
METHYL NAPHTHALENE	MNA	D									397
2-METHYL PENTENE	MPN	D									398
2-METHYLPYRIDINE	MPR	O									399

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CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CB PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
1-METHYLPYRROLIDONE	MPY	D									400
ALPHA-METHYLSTYRENE	MSR	O		50	100		5.4E3				401
MINERAL SPIRITS	MNS	D		100		5000	3.4E4		DQ		402
MONOCHLORODIFLUOROMETHANE	MCF	O		1000	1250	20000			D		403
MONOCHLOROTETRA LUOROETHANE	MTE	O									404
MONOCHLOROTRIFLUOROMETHANE	MCM	O									405
MONOETHANOLAMINE (ETHANOLAMINE)	MEA	O		3	6	1000	5.3E2		D		406
MONOISOPROPANOLAMINE	MPA	O									407
MORPHOLINE	MPL	O	SKIN	20	30	8000	9.2E3	Q	DQ		408
MOTOR FUEL ANTIKNOCK CMPDS (PB ALKYLS)	MFA	O	SKIN	0.10 MG/M3 (PB)		40	6.6E3				409
NAPHTHA AROMATIC (10% OR LESS BENZENE)		D		100						D	410
NAPHTHA COAL TAR	NCT	O		300		10000	3.9E3				411
NAPHTHA CRACKING FRACTION		D		100							412
NAPHTHA HEAVY		D		100							413
NAPHTHALENE	NTM	O		10	15	500	1.3E3				414
NAPHTHA PARAFFINIC		D		100							415
NAPHTHA PETROLEUM		D		100		10000				D	416
NAPHTHA SOLVENT	NSV	D		100		5000			D		417
NAPHTHA STODDARD SOLVENT	NSS	D		100	200	5000	3.9E3	Q	Q	D	418
NAPHTHA VM & P (75% NAPHTHA)	NVM	D		300	400	5000	3.9E3		D		419
NAPHTHENIC ACID	NTI	D									420
NITRIC ACID	NAC	O		2	4	100	4.3E4	DQ	DQ		422
NITRIC ACID (70% OR LESS)	NCD	O		2	4	100	4.3E4		D		423
NITROBENZENE	NTB	O	SKIN	1	2	200	2.6E2				424
NITROGEN, LIQUIFIED	NXX	O									425
2-NITROPHENOL	NTP	O									427
1-NITROPROPANE	NPN	O		25	35	2300	9.9E3				428
NITROPROPANE (1-, 2-, AND MIXTURES)	NPM	O		10 (2-)	20 (2-)	2300					429
2-NITROPROPANE	NPP	O		10	20	2300	1.7E4				430
NITROPROPANE (60%), NITROETHANE (40%)	NNM	O		10 (2-)	20 (2-)	2300					431
O-NITROTOLUENE	NIE	O	SKIN	2		200	1.3E3				432
NITROTOLUENE (O, P, AND MIXTURES)	NIT	O	SKIN	2		200					433
P-NITROTOLUENE	NTT	O		2		200	1.3E2				434
NONANE	NAN	D		200	250	5000	1.3E4				435
NONANOIC ACID		D					1.3E3				436
NONANOIC-TRIDECANOIC ACID MIXTURE		D									437
NONENE	NON	D									438
1-NONENE	NNE	D									439
NONYL ALCOHOL		D					3.9E2				440
NONYL PHENOL	NNP	D									441
NONYL PHENOL (ETHOXYLATED)		D									442
NONYL PHENOL SULFIDE (30% OR LESS)		D									443
OCTADECENE		D									444
OCTADECENEAMIDE (OLEAMIDE)		D									445
OCTANE	OAN	D		300	375	3700	1.4E4	Q	DQ		446
OCTENE		D									447
OCTYL ACETATE		D					5.3E2				448
ISO-OCTYL ALCOHOL		D					4.0E3				449
N-OCTYL ALCOHOL		D									450
OCTYL EPOXYTALLATE	OET	D									451
OCTYL PHTHALATE		D		5 MG/M3							452
OIL: CLARIFIED	OCF	D							D		453
OIL: CRUDE (SOUR)	OIL	D		10 (H2S)					D		454
OIL: DIESEL	ODS	D							D		455
OIL, EDIBLE: BEECHNUT		D									456

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CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CS PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
OIL, EDIBLE: CASTOR	OCA	D									457
OIL, EDIBLE: COCOA BUTTER		D									458
OIL, EDIBLE: COCONUT	OCC	D									459
OIL, EDIBLE: COCONUT OIL, ESTERIFIED		D									460
OIL, EDIBLE: COCONUT OIL, FATTY ACID		D									461
OIL, EDIBLE: COCONUT OIL, METHYL ESTER		D									462
OIL, EDIBLE: COD LIVER		D									463
OIL, EDIBLE: CORN		D									464
OIL, EDIBLE: COTTONSEED	OCS	D									465
OIL, EDIBLE: COTTON SEED FATTY ACID		D									466
OIL, EDIBLE: FISH	OFS	D									467
OIL, EDIBLE: GRAPESEED		D									468
OIL, EDIBLE: GROUNDNUT		D									469
OIL, EDIBLE: HAZELNUT		D									470
OIL, EDIBLE: LARD	OLD	D									471
OIL, EDIBLE: MAIZE		D									472
OIL, EDIBLE: MUSTARD SEED		D									473
OIL, EDIBLE: NUTMEG BUTTER		D									474
OIL, EDIBLE: OLIVE	OOL	D					2.7E3				475
OIL, EDIBLE: PALM	OPM	D									476
OIL, EDIBLE: PEANUT	OPN	D					2.7E3				477
OIL, EDIBLE: POPPY		D									478
OIL, EDIBLE: RAISIN SEED		D									479
OIL, EDIBLE: RAPESEED		D									480
OIL, EDIBLE: RICE BRAN		D									481
OIL, EDIBLE: SAFFLOWER	OSF	D									482
OIL, EDIBLE: SALAD		D									483
OIL, EDIBLE: SESAME		D									484
OIL, EDIBLE: SOYA BEAN	OSB	D					2.7E3				485
OIL, EDIBLE: SOYBEAN (EPOXIDIZED)		D									486
OIL, EDIBLE: SUNFLOWER SEED		D									487
OIL, EDIBLE: TUCUM	OTC	D									488
OIL, EDIBLE: VEGETABLE	OVG	D									489
OIL, EDIBLE: WALNUT		D									490
OIL, FUEL: NO. 1 (KEROSENE)	OON	D		100 MG/M3					D		491
OIL, FUEL: NO. 1-D	OOD	D		100 MG/M3					D		492
OIL, FUEL: NO. 2	OTW	D							D		493
OIL, FUEL: NO. 2-D	OTD	D							D		494
OIL, FUEL: NO. 4	OFR	D							D		495
OIL, FUEL: NO. 5	OFV	D							D		496
OIL, FUEL: NO. 6	OSX	D							D		497
OIL, MISC: ABSORPTION	OAS	D									498
OIL, MISC: ALIPHATIC		D		5 MG/M3					D		499
OIL, MISC: ANIMAL		D									500
OIL, MISC: AROMATIC (5% OR LESS BENZENE)		D		5 MG/M3					D		501
OIL, MISC: AVIATION F2300		D		5 MG/M3							502
OIL, MISC: CASHEW NUT SHELL	OCN	D									503
OIL, MISC: COAL		D		5 MG/M3					D		504
OIL, MISC: COAL TAR	OCT	D									505
OIL, MISC: CROTON	OCR	D									506
OIL, MISC: GAS, LOW POUR		D							D		507
OIL, MISC: GAS, LOW SULFUR		D							D		508
OIL, MISC: HEARTCUT DISTILLATE		D		5 MG/M3							509
OIL, MISC: LANOLIN		D									510
OIL, MISC: LINSEED	OLS	D									511

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CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CB PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
OIL, MISC: LUBRICATING	OLB	D		5 MG/M3					D		512
OIL, MISC: MINERAL	OMN	D		5 MG/M3					D		513
OIL, MISC: MINERAL SEAL	OMS	D									514
OIL, MISC: MOTOR	OMT	D		5 MG/M3					D		515
OIL, MISC: NEATSFOOT	ONF	D									516
OIL, MISC: OITICIA		D									517
OIL, MISC: PENETRATING	OPT	D									518
OIL, MISC: PERILLA		D									519
OIL, MISC: PILCHARD		D									520
OIL, MISC: PINE		D									521
OIL, MISC: RANGE	ORG	D									522
OIL, MISC: RESIDUAL		D							D		523
OIL, MISC: RESIN	ORS	D									524
OIL, MISC: RESINOUS PETROLEUM		D									525
OIL, MISC: ROAD	ORD	D									526
OIL, MISC: ROSIN	ORN	D									527
OIL, MISC: SEAL		D									528
OIL, MISC: SOAPSTOCK		D									529
OIL, MISC: SPERM	OSP	D					2.6E3				530
OIL, MISC: SPINDLE	OSD	D									531
OIL, MISC: SPRAY	OSY	D									532
OIL, MISC: TALL	OTL	D					2.0E3				533
OIL, MISC: TALL, FATTY ACID		D									534
OIL, MISC: TANNER'S	OTN	D									535
OIL, MISC: TRANSFORMER	OTF	D							D		536
OIL, MISC: TUNG		D									537
OIL, MISC: TURBINE	OTB	D									538
OIL, MISC: WHALE		D									539
OIL, MISC: WHITE (MINERAL)		D		5 MG/M3							540
OIL, MISC: WOOD		D									541
OLEIC ACID	OLA	D					1.3E3				542
OLEUM	OLM	O		1 MG/M3					D		543
OLEYL ALCOHOL (OCTADECANOL)		D									544
ORGANIC AMINE 70		D									545
PARALDEHYDE	PDH	O		1.5 MG/M3		15 MG/M3	3.3E4				548
PENTACHLOROETHANE	PCE	O					4.5E3				549
PENTADECANOL	PDC	O									550
1,3-PENTADIENE	PDI	O									551
PENTAETHYLENE GLYCOL		D									552
N-PENTANE	PTA	D		600	750	5000	5.7E5	DG	DG		553
1-PENTENE	PTE	D					5.3E5				554
PERCHLOROETHYLENE(TETRACHLOROETHYLENE)	PER	O		50	200	500	2.1E4	DG	DG		555
PETROLATUM	PTL	D									556
PHENOL	PHN	O	SKIN	5	10	100	4.7E2	DG	DG		557
PHOSPHORIC ACID	PAC	O		1 MG/M3	3 MG/M3		3.9E1				558
PHOSPHORIZED BICYCLIC TERPENE		D									559
PHOSPHORUS, WHITE	PPW	O		0.1 MG/M3	0.3 MG/M3						560
PHTHALATE PLASTICIZERS		D									561
PHTHALIC ANHYDRIDE	PAN	O		1	4	5	6.6E1				562
PINENE		D									563
POLYALKENYL SUCCINIC ANHYDRIDE AMINE		D									564
POLYAMINE, AMIDE MIXTURE		D									565
POLYBUTENE	PLB	D									566
POLYETHYLENE GLYCOL		D									567
POLYETHYLENE POLYAMINES	PEB	O									568

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CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CS PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO
POLYISOBUTYLENE		D									569
POLYMERIZED ESTER		D									570
POLYMETHYLENE POLYPHENYL ISOCYANATE	PPI	O		0.01		5					571
POLYPROPYLENE	PLP	D									572
POLYPROPYLENE GLYCOL	PGC	D									573
POLYPROPYLENE GLYCOL METHYL ETHER	PGM	D									574
POLYSTYRENE DIALKYL MALEATE		D									575
POLYVINYLBENZYLTRIMETHYL AMMONIUM CHLORI	PVB	O									576
PROPANE	PRP	O				20000	1.0E6		DG		577
N-PROPANOLAMINE	PLA	O					2.8E3				578
PROPIONALDEHYDE	PAD	O		4000			3.4E5			D	579
PROPIONIC ACID	PNA	O		10	15		3.2E3		D		580
PROPIONIC ANHYDRIDE	PAH	O					1.3E3				581
PROPIONITRILE	PCN	O	SKIN	6			5.1E4		G		582
N-PROPYL ACETATE	PAT	D		200	250	8000	3.3E4	G	G		583
N-PROPYL ALCOHOL	PAL	D	SKIN	200	250	4000	1.9E4	DG	DG		584
N-PROPYLAMINE	PRA	O					3.2E5				585
PROPYL BENZENE		D					3.3E3				586
PROPYLENE	PPL	O		1000	1250	10000	1.0E6	G	DG		587
PROPYLENE BUTYLENE POLYMER	PBP	D									588
PROPYLENE GLYCOL	PPG	D					2.6E2				589
PROPYLENE GLYCOL METHYL ETHER	PME	D		100							590
PROPYLENE OXIDE	POX	O		20		2000	5.9E5		DG		591
PROPYLENE POLYMER		D									592
PROPYLENE TETRAMER	PTT	D									593
PROPYLENE TRIMER		D									594
PSEUDOCUMENE (1,2,4-TRIMETHYLBENZENE)		D		25		8000					595
PYRIDINE	PRD	O		5	10	3600	2.4E4	DG	DG		596
RUM		D							D		597
SILICON TETRACHLORIDE	STC	O		C5 (HCL)		100					600
SODIUM ACETATE, GLYCOL, WATER SOLUTIONS		D									601
SODIUM BOROHYDRIDE (13%)	SBI	O									602
SODIUM BOROHYDRIDE (<=15%), NAOH/SOLUT	SBX	O		2 MG/M3							603
SODIUM CHLORATE (50% OR LESS)	SDD	O									604
SODIUM DICHROMATE SOLUTION (<=69%)(CRVI)	SDL	O		0.05 MG/M3							605
SODIUM HYDROSULFIDE SOLUTION (<=45%)	SHR	O		10 (H2S)							606
SODIUM HYPOCHLORITE SOLUTION (<=15%)	SHP	O									607
SODIUM 2-MERCAPTOBENZOTHIAZOL SOLUTION	SMB	O									608
SODIUM SULFONATE		D									609
STEARIC ACID	SRA	D									610
STEARYL ALCOHOL (OCTADECANOL)		D									611
STYRENE	STY	O		50	100	5000	6.6E3	G	G		612
SULFOLANE	SFL	D					6.6E3		D		613
SULFUR	SXX	O									614
SULFUR DIOXIDE	SFD	O		2	5	100	1.0E6	DG	DG		615
SULFURIC ACID	SFA	O		1 MG/M3			1.3E0	D	D		616
SULFURIC ACID, SPENT	SAC	O		1 MG/M3							617
TALLOW	TLO	D					2.6E3				618
TALLOW FATTY ALCOHOL	TFA	D									619
TALLOW NITRILE		D									620
1,1,2,2-TETRACHLOROETHANE	TEC	O	SKIN	1	5	150	1.7E4		G		621
TETRADECANOL	TTN	D									622
1-TETRADECENE	TTD	D									623
TETRADECYLBENZENE	TDB	D									624
TETRAETHYLENE GLYCOL	TTG	D					1.3E0				625

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CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CS PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
TETRAETHYLENEPENTAMINE	TTP	O									626
TETRAHYDROFURAN	THF	O		200	250	20000	1.9E5	Q	DQ		627
TETRAHYDRONAPHTHALENE	THN	D									628
TETRAPROPYL BENZENE		D									629
TOLUENE	TOL	D	SKIN	100	150	2000	2.9E4	DQ	DQ		631
TOLUENEDIAMINE	TDA	O									632
TOLUENE 2,4-DIISOCYANATE	TDI	O		.005	.02	10	1.3E1		D		633
TOLUENE DIISOCYANATE, DIPHENYLMET DIISOC	TDD	O		.005	.02	10	1.3E1				634
O-TOLUIDINE	TLI	O	SKIN	2		100	1.3E2		Q		635
TRIARYLPHOSPHATE		D									636
1,2,4-TRICHLOROBENZENE	TCB	O		C5			1.3E3		D		637
1,1,2-TRICHLOROETHANE	TCM	O	SKIN	10	20	500	2.5E4		Q		638
TRICHLOROETHYLENE	TCL	O		50	150	1000	7.6E4	Q	DQ		639
1,2,3-TRICHLOROPROPANE	TCN	O		50	75	1000	2.6E3				640
TRICRESYL PHOSPHATE (<1% O-ISOMER)	TCP	D		0.1 MG/M3							641
TRICRESYL PHOSPHATE (>1% ORTHO)	TCO	O		0.1 MG/M3							642
TRIDECANE		D									643
TRIDECANOIC ACID		D									644
TRIDECANOL	TDN	D									645
1-TRIDECENE	TDC	D									646
TRIDECYL BENZENE		D									647
TRIETHANOLAMINE	TEA	O					1.3E1		D		648
TRIETHYLAMINE	TEN	O		10	15	1000	7.0E4	DQ	DQ		649
TRIETHYLBENZENE	TEB	D									650
TRIETHYLENE GLYCOL	TEG	D					1.3E0				651
TRIETHYLENE GLYCOL DIETHYL BUTYRATE		D									652
TRIETHYLENE GLYCOL MONOMETHYL ETHER		D									653
TRIETHYLENETETRAMINE	TET	O									654
TRIETHYL PHOSPHATE		D									655
TRIISOOCTYL TRIMELLITATE		D									656
TRIISOPROPANOLAMINE	TIP	O									657
2,2,4-TRIMETHYL PENTANEDIOL-1,3-DIISOBUT		D									658
TRIMETHYLACETIC ACID	TAA	O									659
TRIMETHYL BENZENE		D		25	35	100					660
TRIMETHYL HEXAMETHYLENE DIAMINE(224,244)	THA	O									661
TRIMETHYL HEXAMETHYLENE DIISOCYANATE	THI	O									662
2,2,4-TRIMETHYL-3-PENTANOL-1-ISOBUTYRATE		D									663
TRIMETHYL PHOSPHITE	TPP	O		2	5	UA					664
TRIPROPYLENE		D									665
TRIPROPYLENE GLYCOL	TGC	D					1.3E1				666
TRIPROPYLENE GLYCOL MONOMETHYL ETHER		D									667
TRIXYLONYL PHOSPHATE		D									668
TURPENTINE	TPT	D		100	150	1900	6.6E3				669
TURPENTINE SUBSTITUTE (WHITE SPIRIT)		D		350 MG/M3							670
UNDECANOL	UND	D									671
1-UNDECENE	UDC	D									672
N-UNDECYLBENZENE	UDB	D									673
UREA, AMMONIUM NITRATE SOLN (> 2% NH3)	UAS	O		25 (NH3)	35 (NH3)						674
N-VALERALDEHYDE	VAL	O		50		UA	3.4E4				675
VINYL ACETATE	VAM	O		10	20	5000	1.2E5	Q	DQ		677
VINYL ACETATE, FUMARATE COPOLYMER		D									678
VINYL CHLORIDE	VCM	O		5		500	1.0E6	DQ	DQ		679
VINYL ETHYL ETHER	VEE	O					5.6E5				680
VINYLIDENECHLORIDE	VCI	O		5	20	5000	5.3E5	Q	DQ		681
VINYL NEODECANATE	VND	O									682

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CHEMICAL NAME	CHRIS CODE	CFR	OTHER ROUTE	TLV-TWA PPM	STEL PPM	IDLH PPM	CS PPM	TLV DT	QUAN DT	QUAL DT	SEQ NO.
VINYLTOLUENE	VNT	O		50	100	500	6.4E3		D		683
WAX: CANDELILLA		D									684
WAX: CARNAUBA	WCA	D									685
WAX: PARAFFIN	WPF	D		2 MG/M3	6 MG/M3						686
WAX: PETROLEUM		D									687
WHITE SPIRIT		D		500		10000					689
WHITE SPIRIT, LOW AROMATIC		D		500		10000					690
WINE		D							D		691
WOOL GREASE		D									692
M-XYLENE	XLM	D		100	150	10000	1.3E4	Q	Q		693
O-XYLENE	XLO	D		100	150	10000	1.3E4	Q	Q		694
P-XYLENE	XLP	D		100	150	10000	1.3E4	Q	Q		695
XYLENE PARASOL		D									696
XYLENOL	XYL	O							D		697
ZINC DIALKYLDITHIOPHOSPHATE	ZDP	D		10 (H2S)							699

TOTAL OF 675 ITEM(S) IN TABLE

APPENDIX B

MHCW SCENARIOS SELECTED FOR FIELD TESTS

B.1. MHCW Scenarios

Job scenarios were developed for all of the MHCW work activities observed during Task I. These scenarios will be published in a Task I report at the conclusion of this project. The following list of MHCW job scenario titles is included to illustrate the types of work activities that have been observed.

A. Tankship Personnel

I. Period Tank Gauging

a. Open
b. Restricted
c. (Scenario Deleted)

II. Tank Top-off

a. Open
b. Restricted
c. (Scenario Deleted)
d. Short loading, shore stop

III. Tank Cleaning

a. Washing
b. Gas freeing
c. Entry for manual cleaning
d. Product line drainage (deck piping)

IV. Miscellaneous Tank Entry

a. Inspection of wall coating material
b. Preloading inspection
c. Equipment inspection and/or repair

V. Bilge Work in Pumproom

VI. Deck Day Work

a. Sandblasting
b. Spray painting
c. Derusting/chipping
d. Equipment maintenance

VII. Hose Hookup and Disconnect

a. Manual
b. (Scenario Deleted)
c. Run-a-round changing

MHCW Scenarios (continued)

VIII. Engine Room

IX. Tank Ballasting Gauging

X. Product Discharge

a. Periodic Gauging
b. Stripping

B. Cargo Quality Control Personnel

I. Tank Entry - Preloading inspection by company or independent surveyors

II. Cargo Sampling (independent cargo surveyor or terminal/ refinery employee)

III. Initial and Final Ullage Rounds

C. Dock Personnel

I. Hose Hookup and Disconnect - Shore Side

II. Hose Hookup and Disconnect - Shipboard

III. Shoreside Manifold Work During Loading

D. Barge Operations Personnel

I. Barge Loading

II. Barge Cleaning

E. USCG Personnel

I. Marine Inspection Office (MIO) Personnel

a. Barge inspection - topside
b. Barge inspection - internals and void spaces
c. Tanker inspection - biennial
d. Tanker inspection - other than biennial

II. Captain of the Port - Pollution Prevention

III. Captain of the Port - Pollution Response

IV. National Strike Force

MHCW Scenarios (continued)

F. Marine Chemist

I. Tank Certification

II. Inertions

G. Offshore Oil and Gas Drilling/Production/Maintenance Personnel

I. Drilling Mud Makeup

a. Emptying bags of solids into mud hopper
b. Sampling and testing for drilling fluid properties

II. Drill Floor

a. Exposure to drilling fluid while making up drill pipe

III. Maintenance of Production Equipment

a. Maintenance work on equipment having wet oil residue
b. Handling of specialty chemicals used for pipe system protection

IV. Maintenance and Repair Activities

a. Welding
b. Sandblasting
c. Spray Painting
d. Paint Chipping

B.2. Merchant Marine - Barge Scenarios Selected for Field Test

The scenarios for tank top-off during open loading and hose disconnection developed from observations during Task I are described in this section. The code given to this scenario is D.I.1.

SCENARIO CODE D.I.1.

1. Scenario Category - Barge Operations Personnel

2. Scenario Title - Barge Loading

3. Scenario Description:

   - Duration of Scenario - 5 hours, 21 minutes

   - Work Practices

     This scenario describes the loading of a 3-tank chemical barge with methanol by two terminal workers. Actual work time on deck was minimal. There were three principal boardings to collect initial and final product samples, to top-off tanks and to disconnect loading hoses. The sequence of events during the loading are given below.

TIME	ELAPSED TIME (min)	EVENT
0919	0	Worker No. 1 boards barge to open tank hatches and deck valves.
0925	6	Worker No. 1 disembarks to dock house.
0930	11	Standby in dock house for delivery of product from tank farm.
0952	33	Loading of tank heels commences.
0953	34	Worker No. 1 boards barge; Worker No. 2 in dock house.
1007	48	Heel loading terminates.
1008	49	Worker No. 2 boards barge to collect liquid heel samples from three tanks and is assisted by Worker No. 1.
1017	58	Sample collection completed, and both workers disembark to dock house. Samples sent to laboratory for purity analysis.
1103	104	Product purity verified; pumping resumed. All personnel in dock house.
1351	272	Worker No. 1 boards barge and commences to top-off all three tanks.
1403	284	Worker No. 1 disembarks.
1419	300	Worker No. 2 boards barge, disconnects hoses at barge manifold, and prepares to collect final product sample.
1420	301	Worker No. 1 disconnects loading hoses on dock, boards barge and assists Worker No. 2 with sample collection.
1440	321	Sample collection and loading complete; workers disembark to dock house.

Both workers attempted to stand upwind of vapor sources so as to minimize exposure to high vapor concentrations.

- o Sources of Exposure and Chemicals Involved

  Sources of exposure included the methanol vapors that were vented from the tank during loading and the evaporation of residual methanol that is released when loading hoses are disconnected.

- o Duration and Frequency of Encounter with Sources

  The following table summarizes the duration of encounters with sources of exposure.

TASK	WORKER NO.	DURATION (MIN)
Initial Tank Sampling	1	58
	2	56
Tank Top-off	1	12
Final Tank Sampling and Hose Disconnect	2	21
	1	20

4. Pertinent Chemical Data

	Methanol	Reference
Vapor Pressure at 20°C	100mm Hg	Chemical Data Guide*
TLV-TWA	200 ppm	1983 ACGIH**
TLV-STEL	250 ppm	1983 ACGIH**
Odor Threshold	50 to 2000 ppm	Chemical Data Guide*
LEL	5.5% v/v	Chemical Data Guide*
UEL	36.5% v/v	Chemical Data Guide*
IDLH	25000 ppm	NIOSH Pocket Guide+

* Chemical Data Guide for Bulk Shipment by Water, United States Coast Guard Publication CIM 16616.6, 1982.

** Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienists, 1983.

\+ NIOSH/OSHA Pocket Guide to Chemical Hazards, DHEW (NIOSH) Publication No. 78-210, August 1980.

5. Occupational Exposures

The following occupational exposures were obtained from personal dosimetry sampling.

TASK	WORKER NO.	SAMPLE NO.	TIME START	TIME STOP	EXPOSURE CONCENTRATION (ppm methanol)
Initial Tank Sampling	1 2	1 2	0919 0921	1017 1017	14 23
Tank Top-off	1	3	1351	1403	249
Final Tank Sampling and Hose Disconnect	2 1	4 5	1419 1420	1440 1440	42 32

6. Protective Clothing

Worker No. 2 wore a clear plastic face shield for splash protection. The shield may have provided some reduction in respirable vapor concentration that would be analogous to a welder's helmet.

7. Instrumentation

- o Current Usage

  None

8. Controls

- o Corporate Engineering and Administrative Controls

  As both workers consistently stood upwind of vapor sources, it is believed that this work practice, albeit unconfirmed, is a corporate administrative control.

- o Existing Governmental Regulations and Applicability

  Methanol is a USCG Subchapter D Chemical. No special vapor venting, gauging, cargo sampling or health related measures are specified for methanol.

- o Recommended control revisions or additions

  None at this time.

B.3 Coast Guard Scenarios Selected for Field Test Evaluation

The three USCG job scenarios selected for the field test are:

Scenario Title	Scenario Code
o COTP - pollution prevention	E.II.2
o MIO - barge internal inspection	E.I.b.5
o MIO - biennial/LOC tanker inspection	E.I.c.1

Copies of the scenarios developed from Task I observations are included for all three of these work activities.

SCENARIO CODE E.II.2

1. Scenario Category - USCG Personnel

2. Scenario Title - Captain of the Port (COTP): Pollution Prevention

3. Scenario Description:

- Duration of Scenario - 35 minutes

- Work Practices

  Two USCG personnel conducted an unannounced inspection at a barge loading facility. Both members of the team stayed on the dock. They did not board the vessel. The inspectors spoke with dockside personnel regarding loading procedures.

  The discussion included a description of venting procedures and protective equipment utilized during loading. No product was being transferred during this scenario. The facility was using a dockside 30 meter vent with an N_2 driven eductor to remove vapors prior to conducting a visual check of ullages.

- Sources of Exposure and Chemicals Involved

  Pyrolysis Gasoline was being loaded onto the barge just prior to USCG arrival. Potential sources of exposure are the benzene, toluene, and xylene vapors being emitted from the dockside vent. In addition, residual product in the cargo lines was allowed to drain into a catch basin. The product then flowed into a holding tank through a four inch drain. A water stream was allowed to run cautiously into the catch basin to wash residual product into the holding tank.

- Duration and Frequency of Encounters with Source

  Breathing zone concentrations were measured with an OVA while the inspector performed his required tasks. The measured levels were 12-20 ppm as methane during the inspection. When the inspectors walked over to the catch basin, a peak of 40 ppm was detected at the breathing zone. This peak exposure was present for less than one minute. Prior to entering the facility, the OVA was calibrated and the background concentration was 10-12 ppm. There was no definable source of exposure. Thus, frequency and duration of encounters are not pertinent.

4. Pertinent Chemical Data - Pyrolysis Gasoline

	Benzene	Reference
Vapor Pressure	76 mm Hg at 20°C	Verschueren*
TLV-TWA	10 ppm	1983 ACGIH**
TLV-STEL	25 ppm for 15 min	1983 ACGIH**
IDLH	2000 ppm	NIOSH/OSHA****
Odor Threshold	4.68 ppm	CHRIS
LEL	1.3%	Verschueren*
UEL	7.9% vol	Verschueren*

	Toluene	Reference
Vapor Pressure	22mm Hg at 20°C	Verschueren*
TLV-TWA	100 ppm	1983 ACGIH**
TLV-STEL	150 ppm for 15 min	1983 ACGIH**
IDLH	2000 ppm	NIOSH/OSHA****
Odor Threshold	0.17 ppm	CHRIS***
LEL	1.27% vol	CHRIS***
UEL	7% vol	CHRIS***

	Xylene	Reference
Vapor Pressure	6 mm Hg at 20°C	Verschueren*
TLV-TWA	100 ppm	1983 ACGIH**
TLV-STEL	150 ppm for 15 min	1983 ACGIH**
IDLH	10,000 ppm	NIOSH/OSHA****
Odor Threshold	0.05 ppm	CHRIS***
LEL	1.1% vol	CHRIS***
UEL	6.4% vol	CHRIS***

5. Occupational Exposures

- o Personal Monitoring (Vapor)

  In addition to the breathing zone OVA measurements cited above, two occupational exposure samples were collected. A passive dosimeter was placed on the left lapel of one of the inspectors. A conventional charcoal tube/sampling pump technique was used to collect a sample on the right lapel of the same inspector. Both samples were analyzed for benzene, toluene, and xylene. The results of the analyses are tabulated below.

* Handbook of Environmental Data on Organic Chemicals, by Karel Verschueren.

** Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienists, 1983.

*** Chemical Hazards Response Information System, Hazardous Chemical Data, Volume CG-446-2, United States Coast Guard, 1974.

****NIOSH/OSHA Pocket Guide to Chemical Hazards, DHEW (NIOSH) Publication No. 78-210, Third Edition, August 1980.

Sample	Chemical	Concentration
passive	Benzene	<0.77 ppm
passive	Toluene	<0.66 ppm
passive	Xylene	<0.72 ppm
charcoal tube	Benzene	<0.94 ppm
charcoal tube	Toluene	<0.80 ppm
charcoal tube	Xylene	<0.69 ppm

- Personal Monitoring (Noise)

  A noise dosimeter was placed on the second inspector during this scenario. The unit was programmed with an 80 dB cutoff, 70 dB baseline, and a 5 dB exchange rate. The unit sampled at a rate of four times per second and indicated two-minute equivalent exposures using dB (A) weighting. There were no noise sources in the immediate area. The highest two-minute equivalent level was 79 dB (A). The Leff exposure was 76 dB (A) during the sampling period.

- Source/Area Sampling - none attempted

6. Protective Equipment

- Current Usage

  Both of the USCG inspectors carried an emergency escape breathing apparatus (EEBA). The EEBA's provide a five minute supply of air for emergency escape.

7. Instrumentation

- Current Usage

  None

8. Controls

- USCG Engineering, Administrative and Protective Equipment Controls

  Chapter 21 of the USCG Marine Safety Manual (CG-495) addresses safety and health for USCG personnel. The USCG maintains an occupational safety and health program that satisfies the OSH Act-1970 and is based on OSHA standards.

- Recommended Control Revisions or Additions

  - Engineering Controls

    None

- o Administrative Controls

  If open loading of a toxic chemical is in progress when the USCG inspectors arrive, they can elect to delay their inspection until the cargo transfer is finished.

- o Protective Equipment

  USCG Inspectors should have a level of respiratory and eye protection that is consistent with the toxicity hazard of the chemicals on board the barge and the operations in progress during the inspection.

SCENARIO CODE E.I.b.5

1. Scenario Category - USCG Personnel

2. Scenario Title - Marine Inspection Office (MIO) Personnel Barge Inspection - Internals and Void Spaces

3. Scenario Description:

   o Duration of Scenario - 104 minutes (11 minutes on Barge No. 1, 93 minutes on Barge No. 2)

   o Work Practices

   This scenario involves two barges. Both barges were to undergo final inspection for acceptance of repairs as the last step in the recertification process.

   The first barge had been in caustic soda service, and the inspector had assessed the status of repairs the previous day. Final inspection on this barge consisted of a visual inspection of weld inserts on the hull exterior. Inspection was accomplished from shore.

   The second barge had been in gasoline/diesel service. All 10 cargo tanks, the bow rake, and the stern void had been certified "safe for workers/safe for hot work" provided ventilation was maintained during all tank entries. Tanks were certified at 20.8% v/v on oxygen, 0% v/v LEL on combustible gas and less than 5 ppm benzene. The competent person's log was up to date and complete.

   The inspector entered six tanks to determine if repairs had been satisfactorily completed. In between tank entries, the inspector conducted a continuing topside inspection which included the diesel power plant for product discharge and the emergency shutdown control.

   o Sources of Exposure and Chemicals Involved

   The potential for exposure to airborne contaminants was judged to be minimal on the first barge. This assessment was substantiated because OVA measurements did not deviate from the general background level of 4 ppm as methane. A member of the project team wore a noise dosimeter and followed the inspector. The source of noise was the venting of air from the pressurized bow rake.

On the second barge, potential sources of exposure included benzene, total hydrocarbon and tetraethyl lead from any gasoline residuals in the cargo tanks. Noise dosimetry continued uninterrupted on the second barge. Noise sources included blower jet noise and noise generated by deck work while the inspector was in the cargo tanks. Exposure to welding fumes and the arc radiation occurred on entry into one tank.

- o Duration and Frequency of Encounter with Source

Barge No. 1

Compressed air noise: 10 minutes.

Barge No. 2

Tank No.	Duration of Entry (min)
1S	4
3P	5
4S	5
5P	5
4P	6
2P	5

The following observations pertain to each tank entry.

Tank 1S The tank was ventilated with the blower operating in supply mode. Blower noise and residual vapors constitute potential sources. OVA readings ranged from 4-7 ppm as methane (general ambient background was 4 ppm).

Tank 3P The tank was not ventilated. OVA readings ranged from 10-20 ppm. Impact noise was created by worker hammering on the deck.

Tank 4S Tank was ventilated with blower in suction mode. Noticeable blower noise. OVA readings were uniform throughout the tank at 10 ppm as methane.

Tank 5P The tank was not ventilated. The odor of gasoline was apparent. OVA readings ranged from 15 to 25 ppm. Deck work above 5P resulted in impact noise.

Tank 4P Upon entry the blower was operating in supply mode. The blower was then turned off for roughly three minutes, and then the blower was restarted. OVA readings were 10 to 12 ppm. The tank contained visible welding fumes. Roughly two minutes into the entry, a welder struck an arc and laid a weld bead to complete a repair.

Tank 2P Blower status was not noted. OVA readings were 18 to 25 ppm. Welding fumes remained airborne from a recently completed repair. A source of noise was generated when the diesel engine for product discharge was started.

All tanks were extremely dry. Oxygen content of each tank was measured and found to be acceptable (20.6 to 20.8% v/v).

4. Pertinent Chemical Data

	Benzene	Reference
Vapor	75 mm Hg at 20°C	Chemical Data Guide**
TLV-TWA	10 ppm	1983 ACGIH*
TLV-STEL	25 ppm for 15 min	1983 ACGIH
IDLH	2000	NIOSH/OSHA+
Odor Threshold	4.68 ppm	Chemical Data Guide**
LEL	1.4%	Chemical Data Guide**
UEL	8%	Chemical Data Guide**
	Tetraethyl Lead	
Vapor Pressure	5 to 41 mm Hg at 20°C	Chemical Data Guide**
TLV-TWA (skin)	0.1 mg/m^3	1983 ACGIH*
TLV-STEL (skin)	0.3 mg/m^3 for 15 min	1983 ACGIH
IDLH	40 mg/m^3	NIOSH/OSHA+
Odor Threshold	0.2 ppm	Chemical Data Guide**
LEL	Unavailable	--
UEL	Unavailable	--
	Gasoline	
Vapor Pressure	190 mm Hg at 20°C	Chemical Data Guide**
TLV-TWA	300 ppm	1983 ACGIH*
TLV-STEL	50 ppm for 15 min	1983 ACGIH*
IDLH	0.5 to 1.6% for 5 min	Chemical Data Guide**
Odor Threshold	0.25 ppm	Chemical Data Guide**
LEL	1.4%	Chemical Data Guide**
UEL	7.6%	Chemical Data Guide**

5. Occupational Exposures

- o Personal Monitoring (Noise)

  The inspector's exposure to noise was characterized by instrumenting a project observer who followed the inspector

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* Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienists, 1983.

** Chemical Data Guide for Bulk Shipment by Water, USCG CIM 16616.6, 1982.

\+ NIOSH/OSHA Pocket Guide to Chemical Hazards, DHEW (NIOSH) Publication No. 78-210, Third Edition, August 1980.

\++ Chemical Hazards Response Information System Hazardous Chemical Data, Volume CG-446-2, United States Coast Guard, 1974.

during all activities. The 104-minute cumulative exposure was 86.1 dB. On Barge No. 1, the peak noise level associated with blowdown of the bow rake was 86 dB. On Barge No. 2, peak in-tank noise levels of 90, 92, 99, 101 and 102 dB were generated as a result of blower jet noise and deck hammering.

- Personal Monitoring (Vapor)

  Two occupational exposure samples were collected during the inspector's work on Barge No. 2. The sampling duration encompassed all tank entries. The inspector wore two pump operated dosimeters that were attached to alternate lapels. The charcoal tube sample was analyzed for benzene and total hydrocarbon (THC) through xylene (expressed as hexane). The XAD-2 resin tube was analyzed for tetraethyl lead (TEL). The exposure concentrations are shown below.

Compound	Concentration
BNZ	Less than minimum detectable (0.24 ppm)
THC	0.48 ppm
TEL	Less than minimum detectable (0.01 mg/m^3)

- Source/Area Sampling

  None attempted

6. Protective Equipment

- Current Usage

  Hard hat, coveralls and work boots

7. Instrumentation

- Current Usage

  None

8. Controls

- Corporate Engineering and Administrative Controls

  Marine inspectors should review the Marine Chemist's certificate before performing an internal inspection. They should not enter cargo tanks or void spaces unless all of the requirements stated on the Marine Chemist's certificate are satisfied.

- Recommended Control Revisions or Additions

- o Engineering

  The use of mechanical ventilation during welding (Tank 4P) as well as during post-welding entry into tanks (Tank 2P) should be closely monitored to minimize inhalation exposure to fumes.

- o Administrative

  The Marine Inspector may not enter a cargo tank or void space unless it has been certified Safe for Workers by a Marine Chemist. Special attention must be paid to the Marine Chemist's certificate. Any special requirements listed on the certificate, such as continued ventilation during tank entry, must be followed.

- o Protective Equipment

  Eyes - If welding is to be conducted during in-tank inspection, the welding arcs should be shielded from the Marine Inspector, or the inspector should have eye protection. In this scenario observation, the inspector was not aware that a welder was in the tank.

  Ears - Hearing protection should be worn by the Marine Inspector when they are exposed to high noise levels.

SCENARIO CODE E.I.c.1

1. MHCW Category - USCG Personnel

2. Scenario Title - MIO Personnel - Tanker Inspection Biennial/LOC

3. Scenario Description:

   - Duration of Scenario - 3-1/2 hours (not including lunch break)

   - Work Practices

     This scenario describes an LOC inspection aboard a chemical tanker that was loading Vinyl Acetate, Styrene, and Ethylene Dichloride. During most of the inspection the inspector was walking around on the deck checking piping, flame screens, equipment lockers, fire systems and equipment, safety showers, eye washes, alarms, and PV valves. He also entered the two pumprooms for seven minutes each. The remainder of the inspection was completed in the deckhouse checking and completing paperwork.

   - Sources of Exposure and Chemicals Involved

     The exposures received during this time period were to Vinyl Acetate (VAM), Ethylene Dichloride (EDC), and Styrene (STY) which were all being loaded onto the ship. Chemical vapors were being emitted from open hatches, vent risers, and dripping chemical at a leaking flange.

   - Duration and Frequency of Encounter with Source

     The encounter with VAM occurred when the inspector climbed a B/3 vent to check the flame screen. Since VAM was being vented through this riser the inspector was exposed to a high concentration of chemical vapor. The inspection time was only about 5 seconds since the configuration of the vent prohibited the flame screen from being inspected.

     The encounter with EDC occurred at the manifold drip tray where EDC was dripping. As the inspector walked by the manifold he paused to inspect the hose connections. The exposure lasted approximately 2 minutes.

     The encounter with STY occurred because of vapors venting from an open ullage hatch. The inspector walked by, and downwind of, this vent several times during the inspection.

4. Pertinent Chemical Data

	EDC	STY	VAM	Reference
Vapor Pressure (mmHG)	100	6	90	(1)
TLV-TWA (ppm)	10	50	10	(2)
TLV-STEL (ppm)	15	100	20	(2)
Odor Threshold (ppm)	(40,USA:194 USSR)	0.47	0.28	(3)
LEL (% v/v)	6.2	1.1	2.6	(1)
UEL (% v/v)	16	6.1	13.4	(1)
IDLH (ppm)	1000	5000	--	(4)

Note: EDC = Ethylene Dichloride
STY = Styrene
VAM = Vinyl Acetate

5. Occupational Exposures

o Personal Monitoring

Charcoal tube samples were collected in accordance with the NIOSH-recommended procedures for EDC, STY, and VAM. The exposures as measured on these tubes are summarized below:

Time Period	Chemical Exposure Concentration (ppm) EDC	STY	VAM
0955-1231	0.12	ND*	0.10
1302-1356	ND*	ND*	ND*

*ND = Not Detectable

o Source/Area Sampling

None attempted

6. Protective Equipment

o Current Usage

No protective equipment was used or immediately available in the area. The inspector was dressed in cloth overalls and leather work shoes.

(1) Chemical Data Guide for Bulk Shipment by Water, United States Coast Guard, 1982.
(2) Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienists, 1983.
(3) Verschueren, K., Handbook of Environmental Data on Organic Chemicals, Van Nostrand Reinhold Company, 1977.
(4) NIOSH/OSHA Pocket Guide to Chemical Hazards, DHEW (NIOSH) Publication No. 78-210, Third Edition, August 1980.

7. Instrumentation

- Current Usage

  None

8. Controls

- Corporate Engineering and Administrative Controls

  USCG Marine Safety Manual addresses safety and health for USCG personnel.

- Recommended Control Revisions or Additions

  - Engineering Controls

    Forced ventilation should be in operation during the confined space entries into the pump rooms.

  - Administrative

    The inspectors should be trained to avoid exposures to Chemical vapors. For example, when an inspector boards a vessel, he should first determine the status of the activities. If product is being loaded he should stay crosswind or upwind when possible and postpone the inspection of the mast riser until loading has ceased.

    All confined spaces entered by the inspector should first be measured for oxygen, combustible gas, and toxic gas concentration. For this LOC inspection, the pumproom atmospheres should have been measured by the ship's officer or other person qualified to perform the test.

  - Protective Equipment

    An EEBA should be carried by the inspector for emergency escape in the case of a spill.

B.4 Merchant Marine - Tank Ship Scenarios Selected for Field Test

The two Merchant Marine tank ship scenarios selected for the field test are:

Scenario Title	Scenario Code
o Tank top-off during open loading	A.II.a.3
o Tank entry for preloading inspection	A.IV.b._

The first of these scenarios, developed from the Task I observations is included in this section. The second scenario has not yet been prepared.

SCENARIO CODE A.II.a.3

1. Scenario Category - Tankship Personnel

2. Scenario Title - Tank Top-off - Open

3. Scenario Description:

   o Duration of Scenario - 33 minutes

   o Work Practices

   The following procedure was used to top-off one cargo tank by the open gauging method. To measure ullage during the final stages of loading the gauger used a Lufkin tape. Because of tall expansion trunks and dense on-deck piping, the crew member was not able to gauge the tank by standing alongside it. Instead, he made ullage readings by standing on top of the tank hatch lid. He would lower the tape through the venting ullage opening and make a reading. His breathing zone was about three to four feet directly above the ullage opening. When readings were not being taken, the gauger stayed near the tank with his breathing zone approximately five feet from the ullage opening.

   o Sources of Exposure and Chemicals Involved

   The tank the crew member was topping off was being loaded with methanol. His source of exposure was from methanol vapors that were being vented through the open ullage port.

   o Duration and Frequency of Encounter with Source

   The crewman was near the tank hatch performing the top-off activity for approximately 16 minutes. During this time he gauged the tank seven times. The gauging durations ranged from 10 to 88 seconds with an average of 37 seconds.

4. Pertinent Chemical Data - Methanol

		Reference
Vapor Pressure	92 mm Hg at 20	(1)
TLV-TWA	200 ppm	(2)
TLV-STEL	250 ppm	(2)
IDLH	25,000 ppm	(3)

Odor Threshold	50 to 2000 ppm	(4)
LEL	5.5% vol	(4)
UEL	36.5% vol	(4)

5. Occupational Exposures

   o Personal Monitoring

   The crewman's exposure to methanol vapors was monitored during the 16 minute tank top-off activity. The methanol concentration obtained on the samples was 850 ppm.

   o Source/Area Sampling

   A maximum methanol concentration of 70,000 ppm was measured at the ullage opening with an OVA 108 Organic Vapor Analyzer.

6. Protective Equipment

   None used

7. Instrumentation

   None used

8. Controls

   o Corporate Engineering and Administrative Controls.

   None

   o Recommended Control Revisions or Additions

   o Engineering Controls

   Installation and use of restricted gauging standpipes would eliminate a majority of the gauger's direct contact with venting vapors he would normally receive using the current open gauging method.

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(1) Handbook of Environmental Data on Organic Chemicals, by Karel Verschueren.
(2) Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienists, 1983.
(3) NIOSH/OSHA Pocket Guide to Chemical Hazards, DHEW (NIOSH) Publication No. 78-210, Third Edition, August 1980.
(4) Chemical Data Guide for Bulk Shipment by Water, United States Coast Guard, 1982.

- Administrative Controls

  When open gauging, the potential for inhalation of tank vapors could be reduced by instructing the worker to stand upwind of the ullage port and hold his breath.

- Protective Equipment

  Methanol vapor has poor warning properties. For many people the odor threshold is greater than the TLV-TWA value. Only a supplied air respirator is recommended for eliminating exposure to methanol vapor.

APPENDIX C

ENVIRONMENTAL MONITORING FIELD TEST REPORTS

BARGE TANKERMAN OPERATIONS

- Transfer Hose Disconnection from Barge to Shore
- Open Tank Top-Off

C.1 Background

The objective of these field tests was to evaluate the proposed Safe Work Practices that involve the use of personal protective equipment for two operations that may expose a tankerman to potentially hazardous chemicals. The two operation "scenarios" selected for the field tests were:

(1) transfer hose disconnection from barge to shore,
(2) tank top-off during open loading of cargo.

A company that is involved in transporting chemicals in bulk by barge agreed to permit SwRI to carry out the field tests of the Safe Work Practices during cargo transfer operations on their equipment. The field tests took place during two periods, from March 4th to 6th, and on March 27th and 28th, 1985.

Five separate cargo transfer operations were observed. These were:

(1) discharge of acetone cyanohydrin,
(2) loading of toluene,
(3) loading of vinyl acetate,
(4) loading of methyl alcohol,
(5) loading of benzene.

Each of these transfer operations is described separately in Section C.2. Section C.3 summarizes the main conclusions from the field tests. Sections C.4 and C.5 contain the final versions of the recommended Safe Work Practices for the two barge tankerman scenarios.

C.2 Cargo Transfer Operations

C.2.1 Acetone Cyanohydrin Discharge

o Chemical Data - Acetone Cyanohydrin (stabilized)

Hazard Information:

- CHRIS code, ACY
- Applicable bulk regulations, 46CFR Subchapter O
- Flammability limits, 2.25% to 11% by volume
- Recommended* maximum time weighted average concentration for an 8-hour work period, 5 ppm
- Recommended* short term exposure limit, 10 ppm
- Liquid is poisonous by absorption through the skin
- Vapor is poisonous by inhalation
- Ratio of saturated vapor concentration to TWA-TLV, 210

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* Taken from Material Safety Data Sheet for acetone cyanohydrin.

Liquid Properties:

- Specific gravity, 0.93 (water = 1.0)
- Solubility in water, complete

Vapor Properties:

- Vapor density, 2.9 (air = 1.0)
- Vapor pressure, 0.8 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 0.1% by volume
- Odor threshold, unavailable

o <u>Applicable Operation</u> - Transfer Hose Disconnection

o <u>Potential Chemical Exposures:</u>

- Skin contact with liquid during flange disconnection and draining of the transfer line
- Inhalation of vapor from residue in the drip tray

o <u>Clothing and Protective Equipment Worn</u>:

- Coveralls
- Chemical goggles
- Neoprene gloves
- Hard hat
- Leather shoes
- Life vest when on the barge

o <u>Summary of the Operation</u>

A barge containing a cargo of acetone cyanohydrin was discharged at a marine dock operated by a chemical manufacturing company. The entire unloading operation was performed by two dock tankermen. The tow boat that brought the barge to the dock left the dock area, and the tow boat crew (the boat captain and the barge tankerman) did not assist in the discharge operation.

To discharge the barge's cargo, a flexible hose was connected between the manifold on the barge and the transfer line on the dock that leads to the storage tank on shore. Before attaching the hose, one tankerman removed the blind from the flange on the dock transfer line and drained residue product into the drip tray beneath the flange. To drain this line, the tankerman first put on his gloves and goggles, then loosened the bottom bolt that held the blind in place and opened the valve in a 1/2-inch drain line leading to the drip tray. The drip tray beneath the flange was about 2/3 full of liquid, but some of the liquid was probably water from recent rain storms. While liquid from the transfer line was draining into the drip tray, the tankerman took a deep breath and tried to stand upwind from the tray.

After the liquid in the transfer line had finished draining into the drip tray, the tankerman removed the rest of the bolts and the blind from the flange. A crane was used to raise the hose up in the air and to position one end of the hose close to the flange. One tankerman

maneuvered the hose flange against the flange on the transfer line, and spotted one bolt at the top of the bolt circle. When the two flanges were brought into alignment and a gasket was inserted, the rest of the bolts were inserted and tightened. Finally, the valve in the drain line was closed.

The same procedure was followed to connect the other end of the hose to the manifold on the barge. The hose was positioned close to the manifold using the crane, and one tankerman inserted a single bolt at the top of the flange to spot the hose on the manifold. After the hose was positioned properly on the manifold, the tankermen inserted a gasket, inserted the remaining bolts and tightened them down.

After the cargo tanks on the barge were discharged, the diesel engine that drives the deep well pump on the barge was stopped. A hose connected to a supply of compressed nitrogen was connected to the transfer line on the dock. Nitrogen was used to blow product remaining in the hose back into the barge tank, and to blow product in the transfer line through to the shore tank. In this way, the amount of product remaining in the hose and the transfer line was reduced to a minimum before the hose was disconnected.

Before removing the hose, the tankermen put on their gloves and goggles. The bolts at both ends of the loading hose were loosened at the same time. However, the bolts were removed from the dock side first. The hose was lifted up into the air, using the crane, to allow any product residue that had not been removed during the nitrogen purge to drain back into the barge. The blind was placed back on the flange on the dock transfer line and the bolts were tightened down. Then the valve on the manifold on the barge was closed, and the bolts holding the hose to the manifold were loosened and removed. A small amount of product, less than a teacup full, drained into the drip tray when the bolts were removed. Both tankermen cooperated to remove the hose from the manifold. The open end of the hose was tipped towards the drip tray to allow product to drain. The blind was placed back on the manifold flange and the bolts were tightened. The hose was lifted away from the barge using the crane, and was laid down upon the dock.

o <u>Comments</u>

The dock tankermen had been trained to understand the potential hazards from skin contact and vapor inhalation of acetone cyanohydrin. The tankermen had been provided with chemical goggles and impervious neoprene gloves, and they wore them during the hose connection and disconnection operations.

When loosening a flanged connection, they always removed the bottom bolt first. If liquid under pressure were present, it would spray downwards into the drip tray rather than upwards into the face of the tankerman. When a tankerman got acetone cyanohydrin on his gloves, he rinsed off the gloves with water in an eyewash shower before removing them.

The tankermen also tried to avoid inhaling vapor by standing crosswind from the flanges, and holding their breath when they felt it necessary. The tankermen did not wear either an air purifying respirator or a supplied air respirator during the cargo transfer operation.

During this observation, an operations supervisor and personnel from the safety department of the dock operating company answered questions about the potential vapor inhalation hazard from acetone cyanohydrin. They said that their air sampling studies have not indicated the need to provide respiratory protection for the dock tankermen. This is due in part to two factors, (1) acetone cyanohydrin has a relatively low vapor pressure, and (2) the discharge operation is performed in the open air where the wind helps to diffuse vapors.

The company representatives were asked whether the dilution of acetone cyanohydrin with water in a drip pan could present an additional inhalation hazard due to decomposition into hydrogen cyanide gas. They said that acetone cyanohydrin is usually stabilized against decomposition by a low pH. The decomposition reaction will produce hydrogen cyanide, but both the acetone cyanohydrin and hydrogen cyanide are soluble in water, and would not necessarily produce a cloud of gas. The company tries to see that drip pans and trays are kept dry. Also, the decomposition reaction is not instantaneous, but is relatively slow. Therefore, they did not expect the dock tankermen to receive a significant exposure to hydrogen cyanide vapors from the drip trays.

The dock does have a Safe Work Practice for the dock operations. The Safe Work Practice is reviewed by an operations supervisor and two dock tankermen annually.

C.2.2 Toluene Loading

o Chemical Data - Toluene

Hazard Information:

- CHRIS code, TOL
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 1.27% to 7.0% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 100 ppm
  - o TLV-STEL, 150 ppm
- Ratio of saturated vapor concentration to TLV-TWA, 368

Liquid Properties:

- Specific gravity, 0.87 (water = 1.0)
- Solubility in water, negligible

Vapor Properties:

- Vapor density, 3.14 (air = 1.0)
- Vapor pressure, 28 mm Hg at 25 C

- Saturated vapor concentration at 25 C, 3.7% by volume
- Odor threshold, 0.17 ppm

o Applicable Operation - Open Tank Top-Off

o Potential Chemical Exposure:

- Inhalation of vapor when tankerman looks into the tank during loading

o Clothing and Protective Equipment Worn:

- Long sleeve shirt
- Long trousers
- Leather shoes
- Full face mask air purifying respirator
- Neoprene gloves
- Life vest when on the barge

o Summary of the Operation

The loading of a barge with a cargo of toluene was performed by a barge tankerman at a marine terminal operated by a petrochemical refining and manufacturing company. The tow boat crew consisted of the boat captain and two barge tankermen. The tankermen worked alternate shifts of 6 hours duration.

During cargo loading it is the responsibility of the tankerman to see that the barge is loaded evenly, and that cargo is not spilled. Since the likelihood of a spill is greatest when a tank is full, tankermen prefer to avoid having to top-off several tanks simultaneously. Therefore, tankermen follow a loading procedure that allows them to top-off the cargo tanks one at a time.

During this observation, three tanks were to be fully loaded with toluene. The tankerman adjusted his cargo tank values so that the tank near the stern was loaded at a higher rate than the tanks further forward. In this way, he was able to top-off the cargo tanks in sequence, rather than all at the same time. As the stern tank was topped-off, the tankerman decreased the flow of cargo to the stern tank and increased the flow to the forward tanks by adjusting the settings of the cargo tank valves.

To gauge the level of cargo in each tank, the tankerman opened the ullage hatches, removed the flame screen and looked into the tanks. The tankermen also checked the trim of the barge by reading the draft markings on the side of the barge.

For the purpose of evaluating the Safe Work Practice for tank top-off, the tankerman on duty agreed to wear an air purifying respirator and impervious gloves whenever he looked into the tank and gauged the cargo level. Since the tow boat did not have this equipment on board, it was provided by SwRI. The air purifying respirator worn by

the tankerman was an MSA Ultra-Twin* facepiece with two GMA cartridges (for organic chemical vapors). The impervious gloves were MSA 14-inch "Gauntlet" neoprene coated gloves.

o Comments

The marine terminal where the loading operation occurred has a safety policy that requires barge tankermen to wear proper clothing and protective equipment during cargo loading of certain chemicals. For toluene, leather shoes, long sleeve shirts, long trousers and a Coast Guard approved work vest or life jacket are required. Protective gloves are optional, and respiratory protection is not required. A full facepiece air purifying respirator must be worn by tankermen during the loading of ethylene chlorohydrin, benzene, pyrolysis gasoline, cumene, n-butyl acrylate, ethylene dichloride and dichloropropane/dichloropropene mixture. A self-contained breathing apparatus (SCBA) is required for cargos containing hydrogen sulfide.

Although the marine terminal safety policy did not require a full facepiece air purifying respirator for the loading of toluene, the tankerman agreed to wear one and comment on its use.

The tankerman was not accustomed to wearing a respirator as he worked. At first, he said that the respirator was uncomfortable, and he removed it when he was not looking into the tank. However, for the last hour of loading, which included the top-off of all three tanks, he wore the respirator continuously. He observed that as he exhaled into the respirator, moisture from his breath condensed on the facepiece and caused it to become cloudy. Normally, the facepiece cleared as fresh air was inhaled into the respirator. However, during tank topoff, the tankerman walked rapidly from one expansion trunk to the next (to check the cargo level) and from the expansion trunks to the sid f the barge (to check the draft). In doing so, he breathed vigorously and found that the facepiece became completely fogged-up and would not clear during inhalation. In order to gauge the tanks visually when the facepiece was fogged, the tankerman had to remove the respirator. The tankerman was concerned about the impaired visibility and the lack of comfort associated with wearing a full facepiece respirator, and said that he would prefer not to have to wear a respirator when he worked.

The tankerman also found that the face mask muffled his voice. To speak with the marine terminal dockmen standing on the dock about thirty feet away, he either had to remove the respirator, or use a walkie-talkie radio. Since the tankerman must communicate with the dockmen during tank top-off, the use of a radio is imperative.

The tankerman had no problems with the neoprene gloves.

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* Ultra-Twin is a registered trademark for MSA's full facepiece respirator with twin cartridge receptacles.

C.2.3 Vinyl Acetate Loading

- o Chemical Data - Vinyl Acetate (inhibited)

  Hazard Information:

  - CHRIS code, VAM
  - Applicable bulk regulations, 46CFR Subchapter O
  - Flammability limits, 2.6% to 13.4% by volume
  - ACGIH threshold limit values for 1984-85
    - o TLV-TWA, 10 ppm
    - o TLV-STEL, 20 ppm
  - Ratio of saturated vapor concentration to TLV-TWA, 11840

  Liquid Properties:

  - Specific gravity, 0.94 (water = 1.0)
  - Solubility in water, 2%

  Vapor Properties:

  - Vapor density, 2.97 (air = 1.0)
  - Vapor pressure, 90 mm Hg at 20 C
  - Saturated vapor concentration at 20 C, 11.8% by volume
  - Odor threshold, 0.12 ppm

- o Applicable Operation - Open Tank Top-Off

- o Potential Chemical Exposure:

  - Inhalation of vapor when tankerman looks into the tank during loading

- o Clothing and Protective Equipment Worn:

  - Short sleeve shirt
  - Long trousers
  - Leather shoes
  - Half face mask air purifying respirator
  - Goggles
  - Impervious gloves
  - Life vest when on the barge

- o Summary of the Operation

The loading of a barge with a cargo of vinyl acetate was performed by a barge tankerman at a marine dock operated by a chemical manufacturing company. The tow boat crew consisted of the same boat captain and barge tankerman that had performed the loading of toluene (see C.2.2).

The vinyl acetate cargo was open loaded into the barge. The tank atmosphere was vented to atmosphere through open ullage hatches with the flame screens in place. During loading the tankerman routinely lifts the flame screen and looks inside to see if the tank is loading

properly. The cargo loading and tank top-off operation was performed in the same manner as for the toluene loading described in C.2.2.

The tankerman on duty agreed to wear an air purifying respirator and impervious gloves whenever he looked into the tank and gauged the cargo level. He was reluctant to wear a full facepiece respirator, but agreed to wear a half face mask respirator and a pair of goggles. The respirator and gloves were provided by SwRI. The goggles were loaned by a representative from the company that operated the marine dock. The air purifying respirator worn by the tankerman was an MSA Comflo*II half mask with two GMA cartridges for organic chemical vapors. The impervious gloves were MSA 14-inch "Gauntlet" neoprene coated gloves.

o <u>Comments</u>

The safety policy of the company that operated the marine dock did not require protective equipment to be worn by barge tankermen. The company's safety rules were applied only to its own employees. The company feels that the safety of the barge tankermen is the responsibility of the tow boat operating company.

The half face mask respirator that was furnished by SwRI was too small and did not fit the tankerman's face well. Commercially available respirators come in three face sizes, and another (larger) size might have provided an adequate fit. Since each person's facial characteristics are different, it is important to determine the size and style of respirator that gives the best fit for each individual user.

By holding the respirator in place with his hand when he looked into the tank, the tankerman was able to get a tight seal of the respirator against his face. He said that the respirator was effective in eliminating the irritation associated with inhalation of vinyl acetate vapor.

The tankerman said that he would wear a respirator during cargo loading if it were required to keep his job. He preferred not wearing a respirator because he disliked having anything on his face. However, he said that the half face mask was not too uncomfortable.

The tankerman was not bothered by the goggles, and he said that it made sense to wear goggles during hose disconnection, and to protect the eyes from irritation from vinyl acetate vapor. He also liked wearing the neoprene gloves, and said that they would be helpful for working with dirty cargos such as #6 oil.

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* Comflo is a registered trademark for MSA's half mask respirator with twin cartridge receptacles.

C.2.4 Methanol Loading

o **Chemical Data** - Methanol

Hazard Information:

- CHRIS code, MAL
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 5.5% to 36.5% by volume
- ACGIH threshold limit values for 1984-85
  - o TLV-TWA, 200 ppm (skin)
  - o TLV-STEL, 250 ppm (skin)
- Ratio of saturated vapor concentration to TLV-TWA, 658

Liquid Properties:

- Specific gravity, 0.79 (water = 1.0)
- Solubility in water, complete

Vapor Properties:

- Vapor density, 1.11 (air = 1.0)
- Vapor pressure, 100 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 13.2% by volume
- Odor threshold, 50 to 2000 ppm

o **Applicable Operation** - Open Tank Top-Off

o **Potential Chemical Exposure**:

- Inhalation of vapor when tankerman looks into the tank during loading

o **Clothing and Protective Equipment Worn**:

- Long sleeve shirt (sleeves rolled to the elbow)
- Long trousers
- Canvas shoes
- Chemical goggles

o **Summary of the Operation**

The loading of a barge with a cargo of methanol was performed by a barge tankerman at a marine terminal operated by a bulk storage company. The tow boat crew consisted of the boat captain and two barge tankermen. The tankermen worked alternate shifts of 6 hours each. Both tankermen took part in the Safe Work Practice evaluation.

The methanol cargo was open loaded into the barge. The tank atmosphere was vented to the open air through open ullage hatches with flame screens in place. During loading the tankermen routinely lifted the flame screen out and looked into the tank to visually gauge the level of cargo in the tank. The loading and tank top-off operation

was performed in the same manner as for the toluene and vinyl acetate loadings described previously.

Both tankermen agreed to wear chemical goggles during the cargo loading and tank top-off operation. Since the tow boat did not have goggles on board, the goggles were provided by SwRI. The goggles were ENCON* 160 chemical splash goggles with EN-FOG coated lens to minimize fogging.

o Comments

The safety policy of the company that operated the marine terminal did not specify clothing or protective equipment requirements for barge tankermen.

Methanol is a highly volatile cargo. Personal exposure monitoring performed on other occasions by SwRI on tankermen during tank top-off of methanol has shown actual exposures of 249 ppm and 850 ppm that approach and exceed the TLV-STEL concentration value. However, methanol is a chemical for which an air purifying respirator is not recommended. Methanol vapor is not absorbed effectively by standard cartridge sorbent materials, and methanol has poor breakthrough warning properties. The odor threshold may exceed the TLV-TWA, and the respirator wearer can be exposed to high vapor concentrations before he can detect the vapor by smell. Only a supplied air respirator is recommended for eliminating exposure to methanol vapor.

During this observation, the tankermen were not asked to wear a respirator. Instead, the tankermen followed their usual practice of standing upwind or crosswind of the vapor plume during loading and top-off to minimize their exposure.

In general, this practice seemed to be effective. A strong wind was blowing across the deck towards shore. However, on one occasion the tankerman on duty was exposed to a high concentration when he leaned over close to the ullage hatch to get a good view of the ladder inside the tank. The wind ceased momentarily, and he jerked his head away from the hatch.

Both tankermen liked the goggles and said that they would wear them during tank top-off operations. Neither man had any trouble with fogging of the lens. One tankerman said that the goggles made his face sweat, but that the lens did not fog. On two occasions he removed the goggles and wiped them with his shirt to remove moisture. He always put them over his eyes when looking into the tank, but wore the goggles above his forehead while walking over the deck of the barge.

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* ENCON is a registered trademark of the Vallen Company

C.2.5 Benzene Loading

o Chemical Data - Benzene

Hazard Information:

- CHRIS code, BNZ
- Applicable bulk regulations, 46CFR Subchapter O
- Flammability limits, 1.4% to 8.0% by volume
- ACGIH threshold limit values for 1984-85
  - o TLV-TWA, 10 ppm
  - o TLV-STEL, 25 ppm
- Ratio of saturated vapor concentration to TLV-TWA, 3950
- Benzene is a suspected carcinogen for man

Liquid Properties:

- Specific gravity, 0.88 (water = 1.0)
- Solubility in water, negligible

Vapor Properties:

- Vapor density, 2.8 (air = 1.0)
- Vapor pressure, 75 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 9.9% by volume
- Odor threshold, 4.7 ppm

o Applicable Operations

- Open tank top-off
- Transfer hose disconnection from barge to shore

o Potential Chemical Exposures:

- Inhalation of vapor when tankerman looks into the tank during loading
- Skin contact with liquid during flange disconnection and draining of the transfer line

o Clothing and Protective Equipment Worn:

- Short sleeve tee shirt
- Long trousers
- Leather boots
- Half face mask air purifying respirator
- PVC coated gloves
- Life vest when on the barge

o Summary of the Operation

The loading of a barge with a cargo of benzene was performed by a barge tankerman at a marine dock operated by a chemical manufacturing company. The tow boat crew consisted of the boat captain and one barge

tankerman. Only the tankerman took part in the cargo loading operation.

The benzene cargo was open loaded into the barge. The tank atmosphere was vented to the open air through open ullage hatches with flame screens in place. During loading the tankerman routinely lifted the flame screen out and looked into the tank to visually gauge the level of cargo in the tank. The loading and tank top-off operation was performed in the same manner as described previously for toluene, vinyl acetate and methanol.

During the hose connection/disconnection operations, the tankerman assisted a dockman. These operations were performed in the same manner as described in C.2.1 for acetone cyanohydrin.

The tankerman agreed to take part in the Safe Work Practice evaluation. He had a pair of PVC coated gloves which he wore during the hose connection/disconnection operations, and a 3M multi-purpose organic vapor/acid gas, disposable, half face mask air purifying respirator that had been given to him at another marine terminal during a previous benzene loading.

The tankerman wore a full beard that completely covered his throat and cheeks. He was aware that his beard prevented a respirator from sealing effectively against his face, but he said that it was his practice to hold the mask tightly against his face with one hand when he looked into the cargo tank. An MSA Comflo II half face piece respirator with two GMA organic vapor cartridges was provided by SwRI to the tankerman for use during cargo loading.

o Comments

The dockman who took part in the hose connection/disconnection operation was clean shaven, and wore long trousers, a short sleeve shirt, a hard hat, leather boots, safety glasses, impervious gloves, and an MSA Comflo II half face mask air purifying respirator. The chemical manufacturing plant that employs the dockman has a "clean-shaven" policy for its own employees. Also, non-employees (such as tank truck drivers) are not permitted to enter the plant through the gates if they have a beard that would prevent them from wearing respiratory protection. However, this policy is not enforced on tankermen who arrive at the loading dock by water. Therefore, the beard worn by the tankerman did not violate plant safety rules.

The dockman was the leader in the hose connection/disconnection operation. At this dock the flexible loading hose and the transfer lines on the dock are purged with nitrogen both from the dock to the barge and from the dock back to the tank farm after every loading or discharge operation. As a result, the transfer lines were dry and no product was released into the drip tray when the flange covers were removed and the loading hose was connected to the barge. Hose disconnection was also performed smoothly with the release of less than a teacup of benzene to the drip tray. The dockman said that purging the transfer lines and hoses thoroughly with nitrogen is their standard procedure, and that very little product is lost to the drip trays.

After finishing with the hose connection operation, the tankerman put on the half face mask respirator, and adjusted the straps. He performed a positive pressure fit test by covering the exhalation valve and exhaling into the mask. He confirmed that air leaked out of the mask through his beard. However, he said that by pushing the mask against his face (thus compressing both his beard and the face mask seal) he could maintain a positive pressure inside the mask.

During the benzene loading operation he held the mask tightly against his face when he looked into the tank, and he said that he could not smell benzene vapor. However, he needed to use his hands during the top-off operation to turn the handle of the cargo tank valve. The valve was downwind of the open ullage hatch and he had to stand in the vapor plume when he turned the valve handle. As a result, he could not compress the mask against his face, and he said that he could smell benzene vapor when he breathed. This observation confirms that facial hair in the respirator seal region does allow chemical vapor to leak into the respirator during normal breathing. If respirators are to be used to eliminate the inhalation of cargo vapors during open tank loading, the tankermen will have to be clean shaven.

The tankerman was asked whether he would be willing to shave off his beard in order to protect himself against the inhalation of potentially hazardous chemicals like benzene. He said that he would give up his beard and would wear a respirator during loading if it meant saving his job. He mentioned that his employer (the tow boat operating company) does not provide him with a respirator for his use, and has given him no instructions concerning what chemicals should require the use of a respirator during loading. The tankerman commented that the MSA respirator was more comfortable to wear than his 3M respirator and that the half face piece respirator did not interfere with his usual activities. He continued to wear the respirator during the hose disconnection operation.

C.3 Conclusions

The objective of the field test evaluations of two proposed Safe Work Practices for barge tankermen was accomplished. The work practices were discussed with the men who routinely perform the operations and were revised to reflect the manner in which the work is actually performed. The final version of the proposed Safe Work Practices appear in Sections C.4 and C.5.

The field test evaluations also identified several practical problems concerning the use of protective equipment that must be considered when these Safe Work Practices are put into effect.

o Poorly Fitting Respirator - Each tankerman should be fitted individually for a respirator to determine the type and size that best fits his face. A tankerman should have the free use of his hands as he works, and he should not have to press the respirator against his face with one hand to establish a seal.

o Fogging of the Respirator Facepiece - Facepiece fogging is a serious problem for full facepiece air purifying respirators. One solution is to use a nosecup inside the respirator. The nosecup fits over the nose and mouth and directs exhaled air to the exhalation valve.

o Facial Hair that Prevents a Respirator Seal - The effectiveness of an air purifying respirator is seriously reduced if facial hair prevents the respirator from sealing against a smooth skin surface. When a tankerman is fitted and provided with an air purifying respirator, he should be taught that a tight face seal is important to prevent contaminated air from entering the mask.

o Which Cartridge to Use for the Chemical Being Loaded - The tankerman's employer (or the company that furnishes protective equipment to the tankerman) should advise the tankerman about when to wear the respirator and which air purifying cartridges to use for the cargo to be loaded. This information should be given to the boat captain when other instructions concerning the charter are transmitted by radio.

o Respirator Comfort - The tankermen who participated voluntarily in the field test evaluation were not accustomed to wearing respirators during their work. Neither tankerman who used the half mask during loading complained about the comfort of wearing the mask. The tankerman who wore the full facepiece respirator said that it was uncomfortable to wear, and he had a problem with facepiece fogging. While the use of a nosecup in the full facepiece respirator will eliminate facepiece fogging, the comfort of wearing a respirator for an extended period of time should be considered. The tankerman should wear the respirator when he is close to a source of vapor. However, he should be permitted to remove the respirator from time to time when he is upwind of (or removed from) all vapor sources to dry his face and to remove moisture from inside the respirator.

o Training Requirements - In general, the dock personnel who took part in cargo transfer operations appeared to be better trained than the boat tankermen in the areas of hazard recognition and the use of protective equipment. The docks had written safety rules that covered the operations performed by their personnel. Also, the dockmen had been trained to know which of the chemicals transferred at their dock required respiratory protection and which did not. In contrast to the dockmen, the boat tankermen relied more on their common sense than protective equipment to protect them from chemical hazards. For example, all tankermen try to minimize the amount of cargo vapor they breath by standing upwind of the open hatches during loading and by holding their breath when they look into tanks. However, they admit that it makes good sense to use goggles, gloves and a respirator in hose connection/disconnection operations, and to use a respirator during cargo loading when the wind is low or they have to stand downwind of an open hatch. To reach the same level of "sophistication" as the dockmen in chemical hazard protection, the tankermen need to be trained in the use of protective equipment and need to be given instructions as to when it should be used.

Finally, the present lack of uniformity on the part of marine dock and terminal operators in applying their safety rules to barge operations affects the use of personal protective equipment by tankermen. As mentioned in Section C.2.2, one marine terminal operator now requires barge tankermen to wear the same type of personal protective equipment as the dockmen are required to wear during the loading of certain hazardous chemical cargos. In a discussion with marine terminal supervision it was learned that this requirement has forced tankermen to shave off their beards, and the tow boat operating companies to provide gloves and full facepiece respirators for the tankermen to wear.

Some of the tankermen who participated in our field evaluation felt that the terminal was denying their freedom to choose whether or not to wear respiratory protection. However, since the marine terminal knows the hazard potential of each chemical that is transferred at the terminal, it is reasonable that the terminal should recommend or require the level of personal protective equipment to be used by barge tankermen during a loading of a particular cargo.

In contrast, the other marine terminals or docks visited did not attempt to recommend or require the use of personal protective equipment by tankermen during cargo loading. This lack of uniformity may be confusing to the tankerman. If one terminal requires him to wear a respirator while loading benzene, but another dock does not, he may be unsure whether the inhalation of benzene vapor is really a hazard to his health.

If the docks where benzene, pyrolysis gasoline and other Subchapter O chemicals are transferred will require (or at least recommend) the use of personal protective equipment by tankermen when these chemicals are transferred, the tow boats will have to provide this equipment for the tankermen to use. Also, the tankermen will become accustomed to using protective equipment for the cargos that are potentially most hazardous to them.

C.4 Safe Work Practice for Transfer Hose Disconnection

The field test evaluation used a preliminary version of the Safe Work Practice for transfer hose disconnection from a barge to shore. During the field test, transfer hose disconnection operations were observed during the discharge of acetone cyanohydrin and the loading of benzene. As anticipated, the preliminary version did not include all of the activities that occurred during hose disconnection. Therefore, the transfer hose disconnection observations described in Sections C.2.1 and C.2.5 were used to guide the modification of the preliminary version, and they are the basis for the present form of the Safe Work Practice.

The Safe Work Practice for transfer hose disconnection presented in this section applies to the transfer of a Subchapter O cargo (that is potentially toxic by inhalation or skin contact) through a flexible hose between a barge and a dock on shore, where the dockman directs the operation. However, the Safe Work Practice can be modified as

required to suite other (special) circumstances. For example, the transfer of cargo from a barge to a dock that uses permanent "chicksan" type loading arms will require only the disconnection of the loading arm flange from the barge manifold. Also, the transfer of cargo from a barge to a ship lying alongside will not involve a dockman, and there will be no provision for purging the hose and transfer line with nitrogen. If the chemical is corrosive and special protective clothing is required to prevent skin contact then the Safe Work Practice should be modified to include it. Therefore, the Safe Work Practice presented here should be viewed not as a standard, but as a model that should be modified to cover the actual activity performed by the tankerman.

SAFE WORK PRACTICE

Operation: Transfer Hose Disconnection from Barge to Shore

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
1 Inspect and put on buoyant work vest or life jacket prior to first boarding the barge.	1 Falling overboard and drowning.	1 A buoyant work vest or life jacket should be worn at all times while you are on the barge.
2 Inspect and put on an air purifying respirator if the chemical product in the transfer line is potentially toxic by vapor inhalation.	2 Inhaling the vapor of chemicals spilled from the transfer line and hose into the drip tray.	2a Verify that the air purification cartridge is correct for the chemical in the transfer lines. 2b Test for air leakage past the facepiece. Adjust the straps to minimize leakage. If you smell a chemical odor in the respirator, replace the cartridges.
3 Inspect and put on chemical goggles, unless a full facepiece respirator is being worn.	3 Liquid chemical splashed into the face and eyes.	3 Clean the goggles or the respirator facepiece to insure clear vision.
4 Inspect and put on impervious gloves	4 Liquid chemical splashed onto the hands and arms.	4 Inspect the gloves for cracks or punctures. Replace if necessary.
5 If a nitrogen purge is available, the dockman may purge the transfer line and the hose to blow residual product into the barge cargo tanks.	5 None.	5 Nitrogen purging is used to minimize the amount of liquid residue in the hose before the hose is disconnected.
6 Assist the dockman in loosening the hose connection at the dock manifold, if requested.	6 Skin contact with liquid chemical.	6 Remove the bolts from the bottom of the flange first, to avoid splashing chemical up into your face.
7 Allow any remaining residual product to drain into the drip tray.	7 Inhalation of chemical vapor.	7 Stand upwind or away from the drip tray during drainage.

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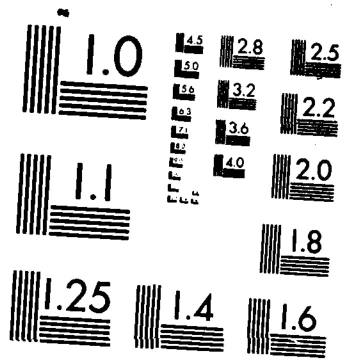

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SAFE WORK PRACTICE

Operation: Transfer Hose Disconnection from Barge to Shore

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
8 Assist the dockman in disconnecting the hose from the dock manifold, as needed.	8 Skin contact with liquid chemical.	8 Avoid contact with liquid chemical.
9 The dockman may use a crane to elevate the free end of the hose. This will drain residual product from the hose into the barge cargo tanks.	9 Falling hose.	9 Stand away from the hose when it is raised into the air.
1Ø Assist the dockman in loosen- the hose connection at the barge manifold, as needed.	1Ø Skin contact with liquid chemical.	1Ø Remove the bolts from the bottom of the flange first, to avoid splashing chemical into your face.
11 Allow any remaining residual product to drain into the drip tray.	11 Inhalation of chemical vapor.	11 Stand upwind or away from the drip tray until draining is finished.
12 Assist the dockman in disconnecting the hose from the barge manifold, as needed.	12 Skin contact with liquid chemical.	12 Avoid contact with liquid chemical.
13 Close the valves on the barge loading manifold, and replace the blinds on the manifold flanges.	13 Skin contact with liquid chemical.	13 Flange blinds must be in place prior to sailing.
14 Remove, inspect, clean and return the protective equipment to its proper storage location.	14 Skin contact with chemical residue on gloves, goggles and respirator.	14a Wash any liquid chemical residue from the gloves before you remove them. 14b Wash, disinfect, dry and store the air purifying respirator. Dispose of cartridges after each use. 14c Wash and dry goggles.

SAFE WORK PRACTICE

Operation: Open Tank Top-Off, Barge Loading

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
1 Inspect and put on buoyant work vest or life jacket prior to first boarding the barge.	1 Falling overboard and drowning.	1 A buoyant work vest or life jacket should be worn at all times while you are on the barge.
2a If the cargo being loaded is a Subchapter O chemical, that is potentially toxic by vapor inhalation, put on an air purifying respirator. 2b If the cargo being loaded is not a Subchapter O chemical, and is not potentially toxic by vapor inhalation, a respirator is not required. But you should always avoid contact with chemical liquids and vapors during loading.	2 Chemical vapor is vented from open ullage hatches during open loading. Inhalation of chemical vapor may cause irritation to the nose, mouth and lungs, and it may cause adverse health effects.	2a Verify that the air purification cartridge is correct for the chemical being loaded. 2b Test for air leakage past the facepiece. Adjust the straps to minimize leakage. If you smell a chemical odor in the respirator, replace the cartridges.
3 Inspect and put on chemical goggles, or wear a full facepiece respirator if the chemical enters the body through the skin, or if the vapor is irritating to the eyes.	3 Chemical vapor contact with the eyes may cause irritation or adverse health effects.	3 Clean the goggles or the respirator facepiece to insure clear vision.
4 Inspect and put on impervious gloves if the tank gauging operation requires you to handle a tape or a gauging rod that may have liquid chemical residue on it.	4 Liquid chemical contact with the hands and arms.	4a Replace gloves with cracks or puncture holes. 4b Rinse any chemical residue from the gloves before you remove the gloves from your hands.
5 Open the ullage hatch cover and remove the flame screen, to gauge the cargo tank.	5 Exposure to chemical vapor.	5 Open the ullage hatch slowly to relieve any back pressure built up in the tank.

SAFE WORK PRACTICE

Operation: Open Tank Top-Off, Barge Loading

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
6 Gauge the tank visually or manually using a tape or a gauging rod.	6 Inhalation of chemical vapor, and skin contact with chemical liquid.	6 Stand cross wind or upwind from the open ullage hatch if possible. Allow the wind to carry vapors away from the hatch area.
7 Adjust the cargo tank valves as necessary to maintain the proper trim during loading.	7 Cargo spill.	7 Check the barge draft periodically.
8 Replace the flame screen each time after gauging the tank.	8 Accidental ignition of cargo tank vapors by a flame or a spark.	8 The flame screen must be in place to prevent a flame or spark from igniting vapors in the cargo tank.
9 Close the cargo tank valve and the ullage hatch cover for each tank as it is topped off.	9 Cargo spill, and inhalation of chemical vapor	9 Be sure that the valve is completely shut to avoid overfilling the tank.
10 Inform the dockman when the loading has about 30 minutes to go.	10 Cargo spill.	10 Advise the dockman to remain in radio (or voice) contact.
11 Gauge the last tank continuously for the last 10 minutes of loading. Alert the dockman to standby the dock shutoff valve.	11 Cargo spill, and inhalation of chemical vapor.	11 Have the dockman reduce the loading rate during top-off if necessary to avoid overfilling the tank.
12 Have the dockman shut off the pump and close the dock loading valve after the last tank is filled.	12 Cargo spill.	12 Observe the cargo tank level to confirm that the level is not increasing after shutdown.

SAFE WORK PRACTICE

Operation: Open Tank Top-Off, Barge Loading

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
13 Replace the flame screen and allow the dockman to purge the transfer line and loading hose with nitrogen.	13 Cargo spill, and cargo tank explosion.	13 Check that the nitrogen purge does not cause the tank to overflow. Have the dockman reduce the flowrate if needed.
14 When purging is finished, prepare to assist the dockman in disconnecting the loading hose, if needed.	14 Cargo spill.	14 Refer to the Safe Work Practice for hose disconnection.
15 Confirm the loading start and stop times with the dockman. Record these times in your logbook.	15 None.	15 None.
16 Observe the cargo inspector and confirm his ullage readings in the cargo tanks that have been loaded. Record his name, company, and the ullage readings in your log-book.	16 None.	16 None.
17 Close and tighten down the latches on all ullage hatches.	17 Cargo spill.	17 All cargo tank entry points must be closed during sailing.
18 Inspect, clean and return the protective equipment worn during loading to its proper storage location.	18 Chemical contamination of protective equipment.	18a Wash, disinfect, dry and store the air purifying respirator. Dispose of used cartridges. 18b Wash and dry gloves, if used. 18c Wash and dry goggles, if used.

APPENDIX D

ENVIRONMENTAL MONITORING FIELD TEST REPORTS

U. S. COAST GUARD PERSONNEL

- COTP, Pollution Prevention Survey
- MIO, Barge Inspection (Internal and Void Spaces)
- MIO, Letters of Compliance Inspection

D.1 Background

The purpose of the field tests was to evaluate and modify the proposed Safe Work Practices for three MHCW scenarios performed routinely by U. S. Coast Guard personnel. The work scenarios selected for the field test evaluation were:

(1) pollution prevention survey, performed by a boarding team from the Captain of the Port (COTP),

(2) inspection of barge internal and void spaces, performed by inspectors from the Marine Inspection Office (MIO),

(3) a biennial or LOC tanker inspection, performed by inspectors from the Marine Inspection Office (MIO).

Permission was received to carry out the field tests with the cooperation of personnel from the Port Safety Station and the Marine Inspection Office in Houston, Texas. The field tests took place during two periods, from March 18th to 20th, and from March 25th to 26th, 1985.

Several operations were observed during the field test period. These operations, and the chemicals involved were:

o Pollution prevention survey boardings,

(1) barge during loading of methanol,
(2) barge during discharge of ethylene dichloride,
(3) barge during loading of naphtha,
(4) barge during loading of #2 fuel oil,
(5) barge during loading of para-xylene.

o Barge internal and void space inspection,

(1) previous cargo, glutaraldehyde.

o Tanker Letter of Compliance inspection,

(1) cargos on board, butadiene and iso-butylene.

These operations are described in Section D.2. Section D.3 summarizes the main conclusions from the field tests. Sections D.4, D.5, and D.6 contain the final versions of the recommended Safe Work Practices for the three USCG MHCW scenarios.

D.2 Field Test Evaluations

D.2.1 Pollution Prevention Survey Boardings

In this section the activities of the Coast Guard boarding team are summarized first. Next, detailed information is given about the hazard potential and the protective equipment used by the boarding team for each of the chemicals encountered. Then, the comments of the boarding team are reported.

D.2.1.1 Summary of the Operation

The boarding team that carries out the pollution prevention survey typically consists of two U.S. Coast Guard personnel. They enter marine facilities where chemical cargo transfers are occurring to perform an inspection of the ships or barges at the dock or terminal. Their inspection may be unannounced, or they may call the marine facility in advance to learn which chemicals are going to be loaded or discharged. All of the boardings observed during the field test period involved barge inspections. Both inspectors carried a Robertshaw emergency escape breathing apparatus (EEBA) that provides a five minute supply of air in an emergency situation.

On arriving at the facility, both inspectors boarded the barge. If cargo loading or discharging was in progress, it was allowed to continue while the inspectors were on board. One inspector obtained the barge's papers from the mail box or storage cylinder where they were stored. He stood or sat on the gangway while he checked the barge's certificate of inspection and endorsements for cargos being transferred. He also checked the tankerman's license, and entered information onto a boarding form (or check list) that he carried with him. When he had finished his review of the barge paperwork, he walked along the barge deck to check other safety items on the check list.

The other inspector carried a second boarding form and he also walked along the barge deck to check particular safety and pollution prevention items on this list. This included checking to see that the flame screens were in place, the emergency shut-down system was operable, warning signs were displayed, the certificate of inspection was completed properly, and that the fire extinguishers on board had been inspected and were in good condition.

The inspectors conferred with the tankerman in charge of cargo transfer to discuss any safety or pollution prevention items that needed correction. If a violation of Coast Guard regulations had been discovered, the boarding team instructed the tankerman to shut down the loading or discharging operation. When the boarding team had finished completing the boarding forms, the inspectors left the barge.

Typically, the Coast Guard inspectors are on the barge for 15 minutes or less. During that time, the primary form of exposure they receive is inhalation of cargo vapors while an open loading operation is in progress. The inspectors try to minimize their exposure to chemical vapors while they perform their inspection. The inspector who checks the barge's paperwork tries to stand upwind or crosswind from cargo vapor plumes. The other inspector who checks the flame screens for damage is more likely to be exposed to cargo vapors. However, he will also try to stand upwind, or to hold his breath as he inspects the screens.

D.2.1.2 Chemical Data

D.2.1.2a **Methanol**

Hazard Information:

- CHRIS code, MAL
- Applicable bulk regulations, 46CFR Subchapter D

- Flammability limits, 5.5% to 36.5% by volume
- ACGIH threshold limit values for 1984-85,
    - o TLV-TWA, 200 ppm (skin)
    - o TLV-STEL, 250 ppm (skin)
- Ratio of saturated vapor concentration to TLV-TWA, 658

Liquid Properties:

- Specific gravity, 0.79 (water = 1.0)
- Solubility in water, complete

Vapor Properties:

- Vapor density, 1.11 (air = 1.0)
- Vapor pressure, 100 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 13.2% by volume
- Odor threshold, 50 ppm to 2000 ppm

D.2.1.2b **Ethylene Dichloride**

Hazard Information:

- CHRIS code, EDC
- Applicable bulk regulations, 46 CFR Subchapter O
- Flammability limits, 6.2% to 16% by volume
- *ACGIH threshold limit values for 1984-85,*
    - o TLV-TWA, 10 ppm
    - o TLV-STEL, 15 ppm (the deletion of this STEL value is included in the list of Intended Changes for 1984-85)
- Ratio of saturated vapor concentration to TLV-TWA, 13,158

Liquid Properties:

- Specific gravity, 1.26 (water = 1.0)
- Solubility in water, slight

Vapor Properties:

- Vapor density, 4.0 (air = 1.0)
- Vapor pressure, 100 mm Hg at 29.4 C
- Saturated vapor concentration at 29.4 C, 13.2% by volume
- Odor threshold, 200 ppm

D.2.1.2c **Naphtha** (Stoddard solvent)

Hazard Information:

- CHRIS code, NNS
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 0.8% to 5.0% by volume
- ACGIH threshold limit values for 1984-85,
    - o TLV-TWA, 100 ppm
    - o TLV-STEL, 200 ppm
- Ratio of saturated vapor concentration to TLV-TWA, 39

Liquid Properties:

- Specific gravity, 0.78 (water = 1.0)
- Solubility in water, negligible

Vapor Properties:

- Vapor density, unavailable
- Vapor pressure, 3 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 0.4% by volume
- Odor threshold, unavailable

D.2.1.2d **#2 Fuel Oil (Diesel oil)**

Hazard Information:

- CHRIS code, ODS
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 1.3% to 6.0% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, unavailable
  - o TLV-STEL, unavailable
- Ratio of saturated vapor concentration to TLV-TWA, unavailable

Liquid Properties:

- Specific gravity, 0.8 to 0.9 (water = 1.0)
- Solubility in water, slight

Vapor Properties:

- Vapor density, varies
- Vapor pressure, 2.6 mm Hg at 50 C
- Saturated vapor concentration at 50 C, 0.3%
- Odor threshold, unavailable

D.2.1.2e **Para-Xylene**

Hazard Information:

- CHRIS code, XLP
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 1.1% to 7.0% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 100 ppm
  - o TLV-STEL, 150 ppm
- Ratio of saturated vapor concentration to TLV-TWA, 132

Liquid Properties:

- Specific gravity, 0.86 (water = 1.0)
- Solubility in water, negligible

Vapor Properties:

- Vapor density, 3.66 (air = 1.0)
- Vapor pressure, 10 mm Hg at 28.3 C
- Saturated vapor concentration at 28.3 C, 1.3% by volume
- Odor threshold, 0.05 ppm

D.2.1.3 Comments

The first barge was loading a cargo of methanol at a marine loading dock when it was boarded. Methanol is a Subchapter D chemical, but has a relatively high vapor pressure. Since an air purifying respirator is not recommended for methanol, the inspector was not asked to wear a respirator when he inspected the flame screens. The inspectors were reminded to take notice of the wind direction, and to always stand upwind or crosswind from vapor plumes emitted from tank vents. One inspector came close to a methanol vapor plume when he visually inspected the flame screens for holes. Neither inspector came into contact with liquid methanol; goggles and impervious gloves were not needed to prevent skin contact.

The second barge was discharging a cargo of ethylene dichloride at a marine terminal. Ethylene dichloride is a Subchapter O chemical, and the boarding team was asked to put on chemical goggles and a half face mask (MSA COMFLO II) air purifying respirator before they boarded the barge. During the inspection it was found that nitrogen was being supplied from shore to inert the cargo tanks during discharge. To prevent the nitrogen from escaping, the ullage caps on the cargo tanks were tightly sealed, and the valve was closed on the vent line leading from the cargo tanks to the common vent stack. These measures are proper engineering controls for preventing a flammable gas mixture from occurring in the cargo tanks, and preventing the release of ethylene dichloride vapor to the open air. As a result, the exposure of the Coast Guard boarding team to ethylene dichloride was negligible, and the respirator and goggles (worn by the boarding team as a personal protection control) were not needed.

The third barge was loading a cargo of naphtha at a marine loading dock when the boarding party arrived. Naphtha is a Subchapter D cargo, with a relatively low vapor pressure. The boarding team were not asked to use special protective equipment for this chemical. During the visual inspection of the flame screens, the inspector was able to stand upwind of the vapor plume and minimize his exposure to naphtha vapor.

The fourth barge had just finished loading a cargo of #2 fuel oil (diesel oil) when it was boarded. #2 fuel oil is a Subchapter D cargo with a very low vapor pressure. Since cargo vapors were not being released from the tank vents (the loading operation was finished), and since #2 fuel oil has relatively low toxicity by vapor inhalation, the boarding team was not asked to wear special protective equipment.

The fifth and final barge to be boarded during the field test observation was loading para-xylene at a marine terminal. Para-xylene is a Subchapter D chemical with a relatively low vapor pressure. The Coast Guard inspectors were asked to put on and wear chemical goggles and a half face mask (MSA COMFLOW II) air purifying respirator while they were on the barge.

The barge had sight glasses on all tanks and a common tank vent header. During this loading operation, the vent riser was lying on its side and releasing vapors at deck level. Each tank also had an open ullage port with a flame screen. Cargo vapors were being vented to the air from each open ullage port as well as from the vent riser. The inspector who checked the flame screens confirmed that he could not smell xylene vapor with his respirator mask on (but he could smell the vapor with mask off). The inspector was pleased with the performance and comfort of the half mask respirator, and said that he would wear one when boarding a barge transporting Subchapter O chemicals. Neither Coast Guard inspector had any problems with the chemical goggles during their boarding inspection.

D.2.2 Barge Inspection (Internal and Void Spaces)

The Safe Work Practice for barge internal inspection was evaluated through discussions with marine inspectors, and by accompanying an inspector on a barge internal inspection. First, a preliminary version of the Safe Work Practice was reviewed with two inspectors assigned to barge and ship repair facilities. Each job activity and safety consideration in the Safe Work Practice was discussed. The marine inspectors' comments concerning how inspections are performed, and their experiences with gas concentration instrumentation, emergency breathing equipment, and protective clothing were recorded. Next, a field test of the Safe Work Practice was performed during a barge internal inspection in a marine repair yard. Following the inspection, the main elements of the Safe Work Practice were reviewed with the inspector. The final recommended version of the Safe Work Practice in Section D.5 reflects both the comments of the marine inspectors and the field test evaluation.

D.2.2.1 Summary of the Operation

The marine inspector enters cargo tanks and void spaces on barges and vessels to inspect for structural damage or to inspect structural repairs either completed or in progress. During his inspection, the marine inspector is often accompanied by representatives from the repair yard and the owner of the barge or vessel.

The marine inspector is trained to recognize the hazards associated with confined space entry. These include (1) oxygen deficiency, (2) flammability, and (3) toxicity of the gas atmosphere contained inside the space. A marine inspector should not enter a cargo tank or confined space unless it has been certified SAFE FOR WORKERS by a licensed Marine Chemist.

Inspectors may come into contact with chemical residue in liquid and vapor form, as well as dust, fumes and noise from grinding, welding and other repair work while the inspection is performed.

The barge internal inspection observed during the field test period was performed in a marine repair facility. The barge was in dry dock, and had been washed and gas-freed in the owner/operator's washing facility prior to arrival at the repair yard. The two previous cargos were iso-propyl alcohol and glutaraldehyde. The cargo tanks and void spaces on the barge were tested by a licensed Marine Chemist, and were certified SAFE FOR WORKERS on the day of the inspection. Two cargo tanks and a wing void space were entered and inspected. The duration of the inspection was less than one hour.

D.2.2.2 Chemical Data

D.2.2.2a **Iso-Propyl Alcohol**

Hazard Information:

- CHRIS code, IPA
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 2.0% to 12.0% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 400 ppm
  - o TLV-STEL, 500 ppm
- Ratio of saturated vapor concentration to TLV-TWA, 109

Liquid Properties:

- Specific gravity, 0.79 (water = 1.0)
- Solubility in water, complete

Vapor Properties:

- Vapor density, 2.07 (air = 1.0)
- Vapor pressure, 33 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 4.3% by volume
- Odor threshold, 200 ppm

D.2.2.2b **Glutaraldehyde** (50% solution or less)

Hazard Information:

- CHRIS code, GTA
- Applicable bulk regulations, 46CFR Subchapter O
- Flammability limits, not flammable
- ACGIH threshold limit values for 1984-85,
  - o TLV-Ceiling, 0.2 ppm (the concentration that should not be exceeded even instantaneously)
- Ratio of saturated vapor concentration to TLV-C, 111,842

Liquid Properties:

- Specific gravity, 1.12 (water = 1.0)
- Solubility in water, soluble

Vapor Properties:

- Vapor density, 3.4 (air = 1.0)
- Vapor pressure, 17 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 2.2% by volume
- Odor threshold, 0.04 ppm

D.2.2.3 Comments

During the discussion of Safe Work Practices, the marine inspectors mentioned two work procedures that they have used to minimize or eliminate particular hazards.

One inspector mentioned the difficulty of making a structural inspection of the void spaces in a barge with double bottoms. Simply crawling through a double bottom that contains the structural framework for the hull is a strenuous activity in itself. Also, the ventilation is often poor, the crawl space is frequently damp or wet, and the framework may be coated with a protective grease to reduce oxidation. If the inspector can tell (by looking at the hull from the outside) that the double bottom has been damaged, he will have the repair yard remove a section of the outer skin covering the region he believes to be damaged. Then, with the skin removed, he can easily and accurately determine the full extent of the damage without having to crawl through the double bottom.

Another concern of marine inspectors is that a barge may be tested and certified by a Marine Chemist several hours before their inspection takes place. During that time it is possible for cargo vapors in the air inside the tank to be "regenerated" from residue that remains on the tank walls after washing. The rate of vapor regeneration increases with increasing temperature. During summer afternoons, when the temperature inside a barge can exceed 40C, vapor regeneration can increase noticeably the vapor concentration inside a tank. To eliminate the potential hazard of vapor inhalation (as well as heat stress), the inspector will arrange to perform his inspection during the early morning. He will ask the repair yard to ventilate the tanks that will be inspected for an hour or more before his inspection starts. Then he will perform the inspection when the air inside the tank is cool and the problem of vapor regeneration is minimized.

The marine inspectors were asked to comment on their use of instrumentation for tank atmosphere measurements, and protective equipment during an inspection. The main points of the discussion are summarized below.

- The marine inspector relies upon a Marine Chemist to test the gas atmosphere inside a tank or void space for oxygen, combustible and toxic vapors and to certify that the tank or space is SAFE FOR WORKERS before the inspector enters the tank. This procedure was being followed satisfactorily in the repair yards visited during the field test.

- Marine inspectors currently do not carry either an O_2 or a combination O_2/CGI instrument with them when they enter a tank or void space. They rely on the Marine Chemist to perform the initial test and on the repair yard's designated Competent Person to retest the space for oxygen and combustible gas concentration. In repair yards where the inspectors have confidence in the Competent Person's ability to make these measurements, this arrangement is satisfactory. However, for an offshore inspection where the space to be inspected has not been certified SAFE FOR WORKERS by a Marine Chemist, or in situations where the inspector may have reason to doubt the ability of the Competent Person to make gas concentration measurements properly, it would be useful to train and equip the marine inspector so

that he can measure the oxygen and combustible gas concentrations himself.

- The marine inspectors have an Emergency Escape Breathing Apparatus (EEBA) available to them, but they prefer not to take it into the tank or void space during a routine inspection. Some of the reasons stated were: (1) an emergency escape situation is not expected to arise in a tank that has been tested and certified by a Marine Chemist and retested periodically by the repair yard's Competent Person; (2) carrying the EEBA increases the difficulty of moving through confined void spaces with exposed structure; (3) in a confined void space, the plastic hood could snag or tear on exposed structural members; (4) the hood could not be worn together with a hard hat. However, the inspectors said that if they felt that an emergency escape situation might arise, they would take the EEBA with them into the tank.

- Usually an inspector wears boots, cotton coveralls, and cotton gloves. He will also have a hard hat if he anticipates bumping hazards, and safety glasses or goggles to wear for chipping. Better protective clothing to prevent skin exposure to chemical residue would be useful for some chemicals. A tank that has carried a high flash point oil may not have been thoroughly stripped and washed (just the area to be inspected for damage) when the inspector enters the tank. Gloves, boots, and the seat of the coveralls may become saturated with oil before the inspection is finished. Inspectors carry a second set of coveralls with them to change into when their first set becomes contaminated.

- A marine inspector should not enter a tank or void space alone. However, if he must do so, he should alert another person working nearby that he is entering a tank, and request that person to check on him periodically. In this way, an inspector who accidentally slips, falls, or strikes his head and needs first aid will be detected.

The field test evaluation of a Safe Work Practice for barge internal inspection was successful. Initially, it was anticipated that the marine inspector would enter another barge that was being placed back into service after having been stored in the fleet for several months. However, the marine inspector learned that the barge did not have a Marine Chemist's certificate, and he declined to perform the inspection until the barge was tested and certified SAFE FOR WORKERS.

Instead, the field test evaluation was performed on another barge that the inspector had entered and inspected earlier that day. The inspector had used a copy of the Chemical Data Guide for Bulk Shipment by Water to look up hazard information on the last two previous cargos, IPA and GTA. He mentioned his conversation with the Marine Chemist who had tested the barge tanks for oxygen, flammability and toxic vapors during the previous day. The Marine Chemist had said that there wasn't a method for measuring the concentration of glutaraldehyde vapor in the tank. However, the next morning the Marine Chemist certified the tank as SAFE FOR WORKERS, and indicated on the certificate the type of portable vapor measuring instrument that he used. The marine inspector had reservations that the instrument named could measure vapor concentrations as low as 0.2 ppm (the

TLV-C value for glutaraldehyde), but he trusted the Marine Chemist's judgement, entered the tank and carried out the inspection without incident.

As part of the field test evaluation, an MSA Model 260 portable O_2/CGI instrument was taken into the tank to measure oxygen and combustible vapor concentration. This instrument is supported by straps that pass around the neck and waist, and it is carried at chest level. The size of the instrument increased the difficulty in entering the exiting the tank through the man entry hatches on the barge. The tank that had contained the glutaraldehyde cargo was being ventilated while the inspector and the project team members were in the tank. The values of oxygen and combustible gas concentration were the same as in the open air above the tank. The instrument was placed in one corner of the tank and the alarm was activated intentionally to learn if an inspector at the other end of the tank could hear the sound above the noise of the ventilation fan. The alarm was audible in all parts of the tank. The instrument was also carried into an unventilated wing void space during the inspection. The measured values of oxygen concentration were uniform throughout the void space. The marine inspector also wore a pair of impermeable neoprene gloves during his inspection. He experienced no problems with the gloves, and said that they would be useful for inspections of dirty tanks.

D.2.3 Tanker Letter of Compliance Inspection

The third scenario selected for field test evaluation was to be a tanker inspection performed by inspectors from the Marine Inspection Office (MIO). The first choice was a biennial inspection, which includes an internal inspection of cargo tanks for structural damage or repair. However, the opportunity for a biennial inspection did not arise during the field test period. Therefore, a Letter of Compliance (LOC) inspection was observed instead.

D.2.3.1 Summary of the Operation

An LOC inspection, accompanied by boardings by the Captain of the Port (COTP) pollution prevention and navigation safety teams, was carried out on a foreign flag LPG and chemical tank vessel carrying butadiene and iso-butylene on abord. The vessel arrived at a marine terminal to discharge and load compliance cargos, but its Letters of Compliance certificates had expired. The vessel was ordered to await inspection by the Coast Guard, and the issuance of new Letters of Compliance before proceeding to transfer cargos.

The inspections performed by the MIO inspectors and COTP boarding teams generally consisted of two phases. The first phase involved looking through the vessel's documents for specific information about cargos carried, vessel safety systems, pollution prevention certificates, etc. The second phase consisted of inspections of ship board systems for navigation and steering, inert gas generation, pollution prevention, fire protection and control, cargo transfer and safety equipment. The inspection teams were usually accompanied by the Chief Mate or the Chief Engineer.

The COTP boarding team inspected the waste treatment (sewage) unit, the navigation lights, the oil/water separator, the deck drains (to ensure

that plugs were in place), drip trays, vents for fuel oil tanks, flame screens, the operation of the steering gear, and the fire control plans. They left the vessel after completing their check list of safety and pollution prevention items.

The MIO inspection team must observe the operation of several of the shipboard systems in order to certify that these systems are in operating condition at the time of the inspection. The systems that were observed included:

- o automatic and remote operation of the steering gear;
- o the control room alarm system;
- o the automatic gas detection system;
- o the emergency cargo loading shutdown system;
- o the inert gas generator;
- o the double door isolation system for the generator room;
- o the automatic deck sprinkler system;
- o the cargo tank high level and overflow alarm system.

The Master arranged for the Chief Mate or the Chief Engineer with the crew's assistance to demonstrate the operation of these systems.

In addition, the inspection team checked the safety equipment (fire suits, chemical protective suits, SCBAs and EEBAs) and the portable gas measuring equipment (oxygen, combustible gas and toxic vapor detection instruments). They also inspected the explosion proof covers on the deep well pump motors and the flame screen on the mast riser vent. When their inspection was finished, they discussed the results of the inspection with the Master, pointing out deficiencies (if any) that needed correction, completed their entries on a new set of Letters of Compliance, and left the vessel.

D.2.3.2 Chemical Data

D.2.3.2a **Butadiene** (inhibited)

Hazard Information:

- CHRIS code, BDI
- Applicable bulk regulations, 46CFR Subchapter O
- Flammability limits, 2.0% to 11.5%
- ACGIH threshold limit values for 1984-85,
    - o TLV-TWA, 10 ppm (this value appears in the list of intended changes for 1984-85)
    - o TLV-STEL, no recommended value
- Ratio of saturated vapor concentration to TLV-TWA, 100,000
- Butadiene was added in 1984-85 to the ACGIH list of industrial substances suspect of carcinogenic potential for man.

Liguid Properties:

- Specific gravity, 0.62 (water = 1.0)
- Solubility in water, Negligible

Vapor Properties:

- Vapor density, 1.88 (air = 1.0)
- Vapor pressure, 1799 mm Hg at 20 C
- Butadiene is a gas confined under pressure at 20C, or a refrigerated liquid at atmospheric pressure
- Odor threshold, above 1000 ppm

D.2.3.2b **Iso-butylene**

Hazard Information:

- CHRIS code, unassigned
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 1.0% to 10% (approximate)
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, unavailable
  - o TLV-STEL, unavailable
- Ratio of saturated vapor concentration to TLV-TWA, none

Liquid Properties:

- Specific gravity, 0.59 (water = 1.0)
- Solubility in water, insoluble

Vapor Properties:

- Vapor density 1.9 (air = 1.0)
- Vapor pressure, 1965 mm Hg at 20 C
- Iso-butylene is a gas confined under pressure at 20 C, or a refrigerated liquid at atmospheric pressure
- Odor theshold, unavailable

D.2.3 Comments

Many of the MHCW scenarios that involve exposure to hazardous chemicals are associated either with cargo transfer operations or cargo tank cleaning and inspection. During the LOC inspection, cargo was not being transferred between the vessel and the marine terminal. Also, an LOC inspection does not require an internal inspection of cargo tanks. Therefore, neither the MIO inspectors nor the COTP boarding party were exposed to significant amounts of cargo vapors during their inspections.

One inspector pointed out that close to the cargo tanks, it is easy to smell the odor of the cargo vapors. However, these odors are the result of fugitive emissions, and do not indicate a significant leak or potential exposure. Normally, the cargo odors can not be detected at a distance of several meters from the tank.

The clothing worn by the MIO marine inspectors included boots, coveralls and a hard hat. Gloves, goggles, and respiratory protection equipment were not needed during their inspection.

The marine inspectors carried a small notebook in which they recorded information during the LOC INSPECTION. They also carried a copy of the *Chemical Data Guide for Bulk Shipment by Water* and a set of Federal Regulations for vessels that carry Subchapter O cargos.

The marine inspectors were asked to comment about potential chemical exposure hazards associated with LOC inspections. One inspector said that pump rooms (without adequate ventilation) present the most significant exposure hazard. If the pump room has a ventilation system, the inspector should have it turned on before he enters the pump room. Another inspector said that most foreign flag chemical carriers are now fitted with deep well pumps, and do not have a pump room. However, oil carriers will still have a pump room.

D.3 Conclusions

The objective of the field test evaluations of the proposed Safe Work Practices for U. S. Coast Guard personnel was accomplished. The work practices were reviewed and evaluated by the people whose work activities can involve exposure to potentially hazardous chemicals. The work practices were revised to reflect the manner in which the work is actually performed. The final versions of the proposed Safe Work Practices appear in Sections D.4, D.5, and D.6.

The following recommendations are based on the observations of the SwRI project team during the field test evaluations. These recommendations have been included in the proposed Safe Work Practices.

Pollution Prevention Survey

o During the field test, the boarding team drove directly to a marine terminal or loading dock without determining in advance whether or not a cargo transfer was scheduled for that day. An alternate approach (which would enforce the use of respirators, but might compromise safety enforcement) would be to call ahead to several facilities to determine:

(1) which chemical products will be transferred;
(2) will the product be loaded or discharged;
(3) does the facility provide a vapor return (loading) or an inert gas line (discharge) to the barge or vessel;
(4) the identity of the barge or vessel involved;
(5) the approximate time when the transfer will occur.

This information will permit the boarding party to determine whether the operations and chemicals to be observed require the use of respiratory protective equipment, and to select the proper type of air purifying cartridge to use for each chemical.

This procedure will require collecting and keeping on file the names and telephone numbers of the people in charge of dock or terminal operations at each facility. This information could be requested by the Captain of the Port by letter to each facility within his jurisdiction.

o The proposed Safe Work Practice in Section D.4 recommends the boarding team to wear either a half mask air purifying respirator or a full face mask air purifying respirator when they board a barge that is open loading a Subchapter O or D chemical cargo that is toxic by vapor inhalation. A respirator is not required:

(1) if the barge is loading Subchapter O or D products that are not toxic;
(2) if the barge is discharging Subchapter O or D products;
(3) if the barge is loading a toxic Subchapter O or D product, and if the cargo vapor is being returned to shore;
(4) if the barge is loading a Subchapter O product, and if the cargo vapor is being vented from a tall riser vent and the wind carries the vapor away from the barge.

The recommendation for the use of respiratory protection during open loading of Subchapter O and Subchapter D products with toxic properties is based on the knowledge that the vapor concentration at tank vents can be more than 1000 times larger than the TLV-TWA or the TLV-STEL for these products. The requirement for respiratory protection could be waived if actual personal exposure data showed that boarding team members did not receive a significant chemical vapor exposure during their boarding activities while these cargos are being open loaded.

o Another method for minimizing the exposure of the pollution prevention boarding team to chemical vapors is to require the marine terminal or dock to suspend an open loading operation while the boarding team is on the barge or vessel. During conversations with barge tankermen, the SwRI project team learned that some Coast Guard inspectors have required the tankermen to suspend a cargo transfer operation while an inspection took place. This policy might be preferred to the alternative of outfitting and training inspectors to use respiratory protective equipment. The policy could be communicated by letter from the Captain of the Port to the marine terminals and docks in his jurisdiction.

Barge Inspection (Internal and Void Spaces)

o The practice of requiring that a Marine Chemist certify a tank or void space as SAFE FOR WORKERS before a marine inspector enters the tank is satisfactory. However, several hours may elapse from the time shown on the Marine Chemist's certificate before the inspector is ready to enter the tank or space. Although a Marine Chemist's certificate is valid for up to 24 hours, the marine inspector should ask that the space be retested if he suspects that physical or atmospheric changes have occurred that affect the safety condition of the tank or space.

The marine inspector can ask the repair yard's Competent Person to retest the tank for oxygen or combustible gas concentration. However, only a Marine Chemist is qualified to retest the tank for toxic vapor concentration (if the tank has contained a toxic material).

If the marine inspector is going to enter a tank that has contained a toxic material, he should ask the repair yard to put a blower on the tank and to continue ventilation for the full time that he is in the tank.

The question of whether a marine inspector should be provided with either an O_2 or combination O_2/CG measuring instrument was discussed frequently during the field test. It was felt that the responsibility for testing and designating the safety condition of the tank or void space should remain with the Marine Chemist. Also, the responsibility for maintaining the safety condition of the tank or space should remain with the repair yard (through the designated Competent Person). Therefore, the purpose of providing an O_2 or O_2/CG instrument to the marine inspector should be to monitor conditions inside the tank, and to provide a warning to the inspector in case he encounters an area of low oxygen or high gas concentration.

In situations where a tank has been certified SAFE FOR WORKERS by a Marine Chemist, and the tank is ventilated continuously while the marine inspector is in the tank, an instrument for monitoring oxygen and combustible gas concentration is probably not needed. However, in situations where (1) a Marine Chemist is not available (for offshore inspections, for example), (2) the marine inspector questions the ability of the repair yard's Competent Person to test the gas atmosphere, or (3) the internal structure inside a tank or void space obstructs ventilation, then providing and training the marine inspector with an O_2 or O_2/CG instrument to use for ensuring his own safety makes sense.

Letters of Compliance Inspection

o The field test carried out on a combination LPG/chemical tanker appeared to indicate that a marine inspector is less likely to be exposed to hazardous chemicals during an LOC than during a barge internal inspection. For many types of vessels, and for many types of cargos, this conclusion may be valid.

However, special cases do exist where the potential for exposure should be considered. Older vessels with pump rooms are one example. The inspector should have the Master turn on ventilation to the pump room, and sample the air in the room with toxic vapor detectors, before the marine inspector enters the room. Inspections of foreign flag vessels that may have sour crude (crude oil containing hydrogen sulfide) on board should also be performed carefully. If the inspector doubts the safety of entering any room or space, he should have the Master test the gas atmosphere first.

D.4 Safe Work Practice for Pollution Prevention Survey

The Safe Work Practice presented in this section applies to the boarding of a barge that is open loading a Subchapter O or D chemical cargo that is potentially toxic by inhalation or skin contact. The Safe Work Practice involves the use of an air purifying respirator to prevent the inhalation of chemical vapor during the inspection.

D.5 Safe Work Practice for Barge Internal Inspection

The Safe Work Practice presented in this section applies to the internal inspection of a barge that has carried either a Subchapter O or D cargo. The marine inspector may not enter and inspect any tank or

enclosed void space unless it has been designated SAFE FOR WORKERS by a Marine Chemist. The use of respiratory protective equipment is not required. However, it is recommended that gloves and boots be worn to guard against skin contact with chemical residue.

D.6 Safe Work Practice for Letters of Compliance Inspection

The Safe Work Practice presented in this section applies to an LOC inspection by a marine inspector. Respiratory protection and special skin protection is not required. It is recommended that the marine inspector call on the Master to test and determine whether enclosed spaces are safe to enter as an administrative protective control.

SAFE WORK PRACTICE

Operation: COTP - Pollution Prevention Boarding and Survey

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
1 Call the marine terminal to determine the chemical cargos to be transferred, the name of the barge, the dock location, whether the transfer is a loading or a discharge, whether a vapor return or inert gas line to shore will be used, and the time of the cargo transfer.	1 None	1 This information is needed to identify transfers of hazardous chemicals, and to select protective equipment.
2 If the barge or vessel will be open loading a Subchapter O or D chemical that is toxic by vapor inhalation, obtain an air purifying respirator from the unit Occupational Health Coordinator.	2 Chemical vapor is vented from open ullage hatches during open loading. Inhalation of chemical vapor may cause irritation to the nose, mouth and lungs, and it may cause adverse health effects.	2a Use a cartridge respirator of the same type and size as you were fit tested for. If you haven't been fit tested, request a fit test to find the size and type of mask that best fits your face. 2b Visually inspect the cartridge respirator. Check that the cartridge is correct for the chemical(s) being open loaded.
3 Obtain an Emergency Escape Breathing Apparatus (EEBA) for emergency use.	3 Toxic chemical vapor.	3 The EEBA furnishes a supply of air that will permit you to escape from a toxic atmosphere.
4 On arrival at the terminal, but before you board the barge or vessel, determine if open loading of a toxic chemical is in progress.	4 None.	4 Obtain this information from the marine terminal supervisor, the mate on watch, or the tankerman on duty during cargo transfer.
5 Bring an EEBA with you when you board the barge or vessel.	5 None.	5 Always carry the EEBA with you on the barge or vessel.

SAFE WORK PRACTICE

Operation: COTP - Pollution Prevention Boarding and Survey

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
6a If a Subchapter O or D chemical with an inhalation health hazard is being open loaded, and the tank atmosphere is being vented from a deck level hatch or vent, put on the air purifying respirator before you board the harge. 6b Respiratory protection is not required if the cargo vapors are captured and returned to shore, or if the vapors are vented from a tall riser vent and blown away from the barge or ship.	6 Inhalation of a toxic chemical vapor.	6a Always wear the air purifying respirator for open loading of toxic chemicals if you suspect that you may be potentially exposed to chemical vapors. 6b If conditions do not require respiratory protection, always stay upwind from any drip tray, or tank vent during cargo load-operations.
7 Perform a visual inspection or transfer lines, pumps, hoses, flame screens, drip trays, and fill in the information required on the boarding form.	7 Inhalation of chemical vapor.	7 Never enter a confined space, unless the space has been certified SAFE FOR WORKERS by a Marine Chemist. If a confined space entry occurs, record the entry and exit times, the number of the Chemists certificate, and the chemicals named, in your exposure logbook.
8 When the pollution prevention survey is completed, leave the barge or vessel, put down the EEBA and remove the respirator.	8 None.	8 None.
9 Return the EEBA and the air purifying respirator to the unit Occupational Health Coordinator.	9 None.	9 Advise the coordinator of any problems associated with the EEBA or the respirator, and of any incidences of potential chemical exposure.

SAFE WORK PRACTICE

Operation: MIO - Barge Inspection

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
1 Obtain a portable oxygen and combustible gas instrument from the unit Occupational Health Coordinator. Verify that the instrument is working.	1a Insufficient oxygen for breathing. 1b Flammable or explosive vapor concentration.	1a Check that the battery of the instrument is charged. 1b Breath into the oxygen sensor. Check to see that the level falls below 19.5%, and that the low oxygen alarm sounds. 1c Check the combustible gas indicator at a known concentration.
2 Obtain impervious gloves from the Occupational Health Coordinator. These gloves should be worn if contact with chemiliquid is likely.	2 Liquid chemical contact with the hands and arms may cause irritation or adverse health effects.	2 Inspect the gloves for cracks or punctures. Replace them if necessary.
3 On arrival at the inspection location, obtain the Marine Chemist's certificate. Verify that the tanks to be entered have been certified SAFE FOR WORKERS.	3 Unsafe working conditions.	3 A Marine Chemist must certify that the tanks to be inspected are safe for entry. The Marine Chemist's Certificate will also list instructions to be followed to maintain the tanks in a safe condition.
4 Obtain the repair yard's Competent Person's logbook. Verify that the tanks have been maintained and retested in accordance with the Marine Chemist's instructions. If the log book is not up to date, have the tank recertified by a Marine Chemist.	4 Unsafe working conditions.	4 After the Marine Chemist's certificate is issued, a designated Competent Person must retest the tank periodically to show that conditions have not changed, in accordance with the Marine Chemist's certificate.

SAFE WORK PRACTICE

Operation: MIO - Barge Inspection

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
5 Verify that the tank to be entered is being ventilated. If the ventilation is off, ask the repair yard to ventilate the tank and to have the Competent Person recheck the oxygen and combustible gas levels.	5a Insufficient oxygen. 5b Flammable vapor concentration. 5c Uncomfortable work conditions due to stale, humid air.	5 If the ventilation has been off for a long period of time, have the repair yard ventilate the tank for 3 to 5 tank volume changeovers before entering.
6 If you believe that the tank is unsafe to enter, you should request that a Marine Chemist retest and recertify the tank as SAFE FOR WORKERS.	6a Insufficient oxygen. 6b Flammable vapor concentration. 6c Toxic vapor concentration.	6 The designated Competent Person is not permitted to certify a tank, or to test for toxic vapors.
7 Before entering a tank or enclosed space, turn on the portable oxygen and combustible gas instrument. Take the instrument into the tank with you to monitor the air in the tank during your inspection.	7a Insufficient oxygen. 7b Flammable vapor concentration.	7 Record the times at which you enter and leave the tank, the number of the Marine Chemist's certificate, and the names of chemicals tested for by the Chemist in your exposure logbook.
8 If either the oxygen or the combustible gas alarm sounds while you are in the tank, LEAVE THE TANK IMMEDIATELY	8a Insufficient oxygen. 8b Flammable vapor concentration.	8 Have a Marine Chemist retest the tank. Do not reenter the tank until it is recertified SAFE FOR WORKERS.
9 When the internal inspection is completed, leave the barge and change out of soiled work clothes.	9 Skin irritation from chemical stains in clothing.	9 Wash hands, arms, face and other affected parts of the body to remove chemical residue.
10 Return gloves and oxygen/combustible gas instrument to Occupational Health Coordinator.	10 Maintenance of equipment.	10 Advise the Coordinator of any problems, and incidences of chemical exposure.

SAFE WORK PRACTICE

Operation: MIO - Letters of Compliance Inspection

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
1 Meet with the Master of the vessel, and obtain information about the cargos on board, and cargos carried on previous voyages.	1 None.	1 Determine whether any of the cargos on board are Subchapter O or D chemicals that are potentially hazardous by vapor inhalation. Refer to the Chemical Data Guide for Bulk Shipment by Water for information.
2 Inspect vessel documents for information about ownership, vessel safety systems, pollution prevention certificates, and the cargos the vessel is permitted to carry. Record the information in your LOC inspection notebook.	2 None.	2 None.
3 Inspect vessel's systems for navigation and steering. Have the Master demonstrate the operation of the steering gear controls from the bridge and from the steering gear room. Test the alarm system and the communications from gear room to bridge.	3 None.	3 None.
4 Have the Master demonstrate the automatic gas detection system (if fitted).	4 None.	4 None.
5 Have the Master demonstrate the operation of the automatic cargo loading shut down system and the automatic valves.	5 Accidental discharge when the automatic valves are tested.	5 Never stand in direct line with any of the cargo lines when the automatic valves are tested.

SAFE WORK PRACTICE

Operation: MIO - Letters of Compliance Inspection

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
6 Have the Master demonstrate the inert gas generation system.	6 None.	6 None.
7 If the vessel has a pump room, have the Master ventilate the room and test for oxygen, combustible gas and toxic gases (if a potentially toxic cargo is carried on board) before you enter the pump room.	7a Oxygen deficiency. 7b Combustible gas atmosphere. 7c Toxic chemical vapors.	7 The vessel should have the instrumentation for measuring oxygen, combustible gas and toxic gas concentration on board. The Master is responsible for testing the pump room and other enclosed spaces to ensure that they are safe to enter.
8 Test the double door isolation system if fitted.	8 None.	8 None.
9 Have the Master demonstrate the automatic deck sprinkler system if fitted.	9 None.	9 None.
10 Have the Master demonstrate the cargo tank high level and overflow alarm system.	10 None.	10 None.
11 Inspect other safety equipment as required by regulation for the cargos carried.	11 None.	11 None.
12 Review the results of the inspection with the Master, identify deficiencies that need correction, and complete entries on new Letters of Compliance.	12 None.	12 None.

APPENDIX E

ENVIRONMENTAL MONITORING FIELD TEST REPORTS

CHEMICAL TANKSHIP OPERATIONS

- Tank Entry for Internal Inspection
- Open Tank Top-Off

E.1 Background

The purpose of these field tests was to evaluate and modify the proposed Safe Work Practices for two MHCW scenarios performed routinely by merchant marine tankermen on chemical tankships. The work scenarios selected for the field test evaluation were:

(1) tank entry for internal inspection,

(2) open tank top-off.

Permission to carry out the field test evaluation was received from a company that transports both Subchapter D and Subchapter O chemical cargos in tankships. The field test took place during the period from April 14th to 15th, 1985.

The operations that were observed during the field test were:

- Tank entry for internal inspection,

    (1) previous cargo, methyl iso-butyl ketone.

- Open tank top-off,

    (1) loading of ethylene dichloride,
    (2) loading of epichlorohydrin,
    (3) loading of ethylenediamine mixture.

These operations are described separately in Section E.2. Section E.3 summarizes the main conclusions from the field tests. Sections E.4 and E.5 contain the final versions of the recommended Safe Work Practices for these scenarios.

E.2 Field Test Evaluation

E.2.1 Tank Entry for Internal Inspection

In this section the activities of the Chief Mate who performed the tank internal inspection are described. Next, detailed information about the hazard potential and the protective equipment used by the Mate is presented. Finally, the comments of the Chief Mate on the Safe Work Practices are reported.

E.2.1.1 Summary of the Operation

On this vessel the cargo tanks are used to carry many different types of cargo ranging from industrial chemicals and gasoline to food products and medicinal grade chemicals. The standard for cargo tank cleanliness is very high in order to prevent contamination.

The cargo tank involved in the internal inspection had been washed, gas freed and inspected at sea. The previous cargo carried in the tank was methyl iso-butyl ketone. Later in the voyage, it was anticipated that this tank would receive either a medicinal grade product or a food product. Therefore, the Chief Mate and a shore based representative from the vessel

operating company performed a second tank inspection. This inspection involved collecting samples of residue from tank bulkhead washings, and any liquid residue in the tank, and testing the samples for presence of hydrocarbons or chlorides.

The Chief Mate had tested the gas atmosphere inside this tank for oxygen, combustible gas and toxic gas concentration a few days before. However, he repeated his test sequence for the field test evaluation. The Mate wore a long sleeve shirt, long trousers, and boots. He also wore clean slip-on shoe covers over his shoes to prevent contaminating the ladder or the tank floor.

As part of the field test evaluation, the Chief Mate was asked to perform tests for oxygen, combustible gas concentration and toxic gas concentration for methyl iso-butyl ketone. He agreed to do so and he gathered together a combination O_2/CG instrument, and a Draeger toxic gas sensing system. Unfortunately, the vessel's supply of acetone 100/A Draeger toxic vapor tubes (used to sample for methyl iso-butyl ketone) had been depleted. The Mate demonstrated that he knew how to leak test and use the Draeger toxic gas measuring system, but it was not possible to test for methyl iso-butyl ketone without the proper tube. The operating company's agent was asked to replenish the supply of Draeger tubes while the vessel was in port.

The Mate used an Edmont combination oxygen and combustible gas analyzer with low oxygen and high concentration alarms to test the tank atmosphere. He verified that the oxygen and combustible gas sensors and alarms were functional by exposing the gas sensor to gas from a butane lighter (this was done in the deckhouse, not on the ship deck). Next, the Mate took the instrument out on the deck and verified that it measured 0% LEL and 21% oxygen before he entered the tank. He lowered the sensor line into the tank and allowed time for it to measure oxygen and gas concentration. When he saw that the concentration measured from the tank top was acceptable, he entered the tank and descended to the first level beneath the open hatch. Again, he lowered the sensor deeper into the tank before descending to the next level. On reaching the bottom of the tank, the gas measuring instrument was placed on the floor and left to operate while the bulkhead washing took place.

The Safe Work Practice for cargo tank entry on board a vessel involves the use of a Confined Space Entry Permit. For the field test, the Entry Permit was filled in by the SwRI project team member. However, the Entry Permit was reviewed with the Chief Mate, and his comments on the use of the Entry Permit are included in Section E.2.1.3.

E.2.1.2 Chemical Data - **Methyl Iso-butyl Ketone**

Hazard Information:

- CHRIS code, MIK
- Applicable bulk regulations, 46CFR Subchapter D
- Flammability limits, 1.4% to 7.5% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 50 ppm
  - o TLV-STEL, 75 ppm
- Ratio of saturated vapor concentration to TLV-TWA, 263

Liquid Properties:

- Specific gravity, 0.80 (water = 1.0)
- Solubility in water, 2%

Vapor Properties:

- Vapor density, 3.45 (air = 1.0)
- Vapor pressure, 10 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 1.3% by volume
- Odor threshold, 0.47 ppm

E.2.1.3 Comments

For cargo tank entries in port or at sea the Chief Mate performs the same type of gas atmosphere testing that a Marine Inspector does in a vessel repair yard. U. S. Coast Guard regulations (46CFR153) specify that the Master of a vessel shall determine that a tank or enclosed space has sufficient oxygen and is free of toxic vapors for certain hazardous chemicals named in Subchapter O. However, methyl iso-butyl ketone (MIK) is not a Subchapter O chemical, and the Mate was not required (under current Coast Guard regulations) to test for MIK vapor before entering the cargo tank.

The Chief Mate said that his tank entry to collect the bulkhead washing samples (observed by the SwRI project team) was not performed in quite the same manner as a tank entry immediately following washing and gas freeing. On his initial entry into a cargo tank the Chief Mate said that he wears a chemical protective suit, and an SCBA. He tests for oxygen and combustible gas at different levels until he has reached the bottom of the tank. He said that he does use Draeger tubes routinely for toxic gas concentration measurement. If the gas concentration is too high, he will wash and gas free the tank again.

Cargo contamination is a very great concern on this vessel. Therefore, it is not unusual for seamen to enter a tank for manual cleaning (mopping up washwater residue). The Chief Mate said that seamen will wear protective clothing when necessary. In particular, slicker suits are used if the last cargo was an acid cargo. The tank is ventilated while seamen are in a tank for cleaning, but ventilation is not used when the Chief Mate makes the final cargo tank inspection.

The use of a Confined Space Entry Permit for routine tank entries was discussed with the Chief Mate. The Mate said that the permit was pertinent to a tank entry operation, and that the check list entries on the permit form represented good operational procedure. He said that performing a tank entry safely was very important, but he did not feel that it was necessary to complete an entry permit form every time that a cargo tank was entered. On that vessel, so many tank entries are performed routinely, that he felt that the paperwork involved in filling in the form and filing it away would consume too much time and effort. The Mate was asked about the value of using a Confined Space Entry Permit for training new officers and crew members during each voyage. He said that an Entry Permit and the check list of items to be considered during a tank entry would be very good for training use.

E.2.2 Open Tank Top-Off

In this section the activities of the deck officer on watch and the crewmen who supervise and perform the tank top-off operation are described. Then, information about the hazard potential of the chemical cargos being loaded, and the protective equipment used by the officer and crew is presented. Finally, comments of the deck officers concerning the top-off operation and protective equipment are reported.

E.2.2.1 Summary of the Operation

On this vessel, tank top-off is performed by a crewman called a "watchman" under the supervision of either the Chief, Second or Third Mate depending on which officer is standing watch. All of the cargos observed during the field test were open loaded, and the cargo tank atmosphere was vented from an open ullage hatch at deck level. Two watchmen were on duty during any watch. The watchmen were responsible for measuring the ullage level manually using a tape and bob. Although the vessel had a closed gauging system for each cargo tank, these systems were not used routinely.

During cargo loading, the watchmen visited each tank about every 30 to 60 minutes, measured the ullage, and recorded the ullage reading in their notebooks. The ullage readings were transferred onto a loading information board placed along the gangway, where it could be seen by the Mate on watch. The Mate calculated the final or "stop" ullage for each tank and recorded the value onto the information board.

Some products were loaded into more than one tank. For these products the Mate would have a watchman adjust the valves on the cargo transfer lines so that the tanks could be topped-off one after the other (rather than all at once).

When a tank was nearing its final ullage, a watchman would remain at that tank, measure the ullage, and inform the Mate. If this was the last tank (or the only tank) being loaded with this chemical, the Mate would call the dockman and ask him to standby to close the dock valve.

When the final ullage was reached, the Mate asked the dockman to close the dock valve and have the tank farm shut the loading pump. Following shutdown, the transfer line and loading hose were purged with nitrogen from the shore. When the purging operation was completed, the ullage hatch was left open for the cargo surveyor to collect samples for analysis. Following sampling by the cargo surveyor the ullage hatch was shut.

During their rounds the watchmen wore coveralls with either long or short sleeves and long pants legs, leather work gloves, leather shoes. During tank top-off they wore full face mask air purifying respirators. The Mate on watch wore the same type of clothing and also had a full face mask air purifying respirator available for use.

Two types of full face mask respirators were used by the crew and officers. These were manufactured by Draeger and by Helly Hansen Moss. All of the full face mask respirators contained nose cups to prevent fogging of

the eyepiece. The respirator masks were used with gas mask cannisters manufactured by AGA Spiro. The cannisters were rated for use in atmospheres containing up to 2% vapor by volume.

E.2.2.2 Chemical Data

E.2.2.2a **Ethylene dichloride**

Hazard Information:

- CHRIS code, EDC
- Applicable bulk resulations, 46CFR Subchapter O
- Flammability limits, 6.2% to 16% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 10 ppm
  - o TLV-STEL, 15 ppm (the deletion of this STEL value is included in the list of Intended Changes for 1984-85)
- Ratio of saturated vapor concentration to TLV-TWA, 13,158

Liquid Properties:

- Specific gravity, 1.26 (water = 1.0)
- Solubility in water, slight

Vapor Properties:

- Vapor density, 4.0 (air = 1.0)
- Vapor pressure, 100 mm Hg at 29.4 C
- Saturated vapor concentration at 29.4 C, 13.2% by volume
- Odor threshold, 200 ppm

E.2.2.2b **Epichlorohydrin**

Hazard Information:

- CHRIS code, EPC
- Applicable bulk regulations, 46CFR Subchapter O
- Flammability limits, 3.8% to 21% by volume
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 2 ppm (skin)
  - o TLV-STEL, 5 ppm (the deletion of this STEL value is included in the list of Intended Changes for 1984-85)
- Ratio of saturated vapor concentration to TLV-TWA, 8224

Liquid Properties:

- Specific gravity, 1.18 (water = 1.0)
- Solubility in water, 6%

Vapor Properties:

- Vapor density, 3.2 (air = 1.0)
- Vapor pressure, 12.5 mm Hg at 20 C
- Saturated vapor concentration at 20 C, 1.6% by volume
- Odor threshold, 10 to 25 ppm

E.2.2.2c **Ethylenediamine Mixture**

This product is a mixture of several different chemicals of the amine family. The material safety data sheet for this product lists 12 substances that are present at concentrations of 1% or greater. Two of these substances have ACGIH TLV values. These substances and their approximate percentages in the mixture are:

o ethylenediamine	33% to 37%
o diethylenetriamine	13% to 17%

Hazard Information:

- CHRIS code, unavailable
- Applicable bulk regulations, 46CFR Subchapter O
- Flammability limits, unavailable
- ACGIH threshold limit values for 1984-85,
  - o TLV-TWA, 10 ppm for ethylenediamine component
    1 ppm (skin) for diethylenetriamine component
  - o TLV-STEL, unavailable
- Ratio of saturated vapor concentration to TLV-TWA, none
- Cargo information sheet gives this information:
  - o Exposure: Eyes - severe burn, possible blindness
    Skin - severe burn, toxic by absorption, allergenic skin reaction (rash)
  - o Inhalation: Has offensive odor, moderately irritating, allergenic respiratory reaction
  - o *Ingestion:* Corrosive - causes burns

Liquid Properties:

- **Specific gravity, 0.96**
- **Solub**ility in water, mixes completely

Vapor Properties:

- Vapor density, greater than 1 (air = 1.0)
- Vapor pressure, less than 10 mm Hg at 20°C
- Boiling point, greater than 100 C
- Odor threshold, unknown

E.2.2.3 Comments

The watchmen and Mates all wore their full face mask air purifying respirators during the tank top-off operations. The Mates act as operations supervisors during cargo loading. They direct the watchmen on the use of protective clothing and respirators. Before the loading operation begins, one of the Mates determines which type of respirator cannister should be used for each of the different chemical cargos to be loaded. The respirator cannisters are not discarded after every use, but are saved for reuse until they lose effectiveness. The date on which cannister is first used is marked with ink on the cannister surface. In this way the older cannisters can be replaced first.

Except for some problems encountered during the open loading of the ethylenediamine mixture, the loading and tank top-off operations went smoothly. The loading of the ethylenediamine was unusual because the vapor plume emitted through the open ullage hatch was highly visible (like steam). None of the other products loaded at this terminal produced a visible plume like the ethylenediamine mixture.

At the start of loading, the tank atmosphere containing the ethylenediamine vapor was allowed to vent from the open ullage hatch. The wind carried the vapor plume over the deck and across the elevated walkway that runs the length of the vessel. Later, one of the Mates determined that the vapor was irritating. He closed the ullage hatch and opened a valve to vent the tank atmosphere from the mast riser vent. This procedure prevented the vapor plume from reaching the level of the deck and the walkway. However, the watchman had to open the ullage hatch periodically to gauge the ullage. When the hatch was opened, it relieved the back pressure on the tank, and produced a puff of vapor that completely enveloped the watchman for about 3 seconds.

During the tank top-off of the ethylenediamine mixture the ullage hatch was left open and both the watchman and the Mate wore chemical protective suits in addition to their full face mask respirator. The watchman had considerable difficulty in seeing the liquid/gas interface to measure the ullage level during top-off. The interface was obscured by the vapor cloud, and vapor from the cloud condensed on the outside of the eyepiece of his respirator.

Although the vessel was expecting the dock to stop the loading (after a predetermined quantity of product had been pumped), the Chief Mate had to direct the dockman to shut down the loading to avoid overfilling the tank. The watchman said that he felt some irritation on his neck from exposure to the chemical vapor, and he was told to wash his face and neck.

E.3 Conclusions

The objective of the field test evaluation of the proposed Safe Work Practices for merchant marine tankermen was accomplished. The work practices were reviewed and evaluated by crew members whose work activities involve the exposure to potentially hazardous chemicals. The work practices were revised to reflect the actual work procedures observed during the field observation. The final versions of the proposed Safe Work Practices appear in Sections E.4 and E.5.

During the field test observation the officers and the crew demonstrated an excellent safety awareness. The officer said that their operating company supports their safety program by purchasing and providing good quality protective equipment and instrumentation. The officers worked together to ensure that the cargo transfer operations were performed safely.

On this vessel, the responsibility for maintaining the protective equipment and conducting training during safety meetings was vested with one of the junior officers. One mate is given the charge of maintaining navigation materials, while the other mate is designated as the safety officer.

During periods of time when the vessel is at sea, safety meetings are held with the crew to demonstrate the proper use of respirators, self contained breathing apparatus (SCBA), protective clothing, and to review tank entry procedures.

E.4 Safe Work Practice for Tank Entry for Internal Inspection

The Safe Work Practice presented in this section applies to an entry into an empty cargo tank that has been washed and gas freed in preparation for loading a new cargo. In general, it pertains to entry into tanks that have carried both Subchapter D and Subchapter O cargos. The Safe Work Practice involves the use of instrumentation for the measurement of oxygen, combustible gas and toxic gas or vapor concentration. It may also require the use of an SCBA, and chemical protective clothing. The use of air purifying respirators inside the cargo tank is not permitted by this work practice.

E.5 Safe Work Practice for Open Tank Top-Off

The Safe Work Practice presented in this section applies to the top-off of a cargo tank during the open loading of a Subchapter O cargo. The Safe Work Practice involves the use of an air purifying respirator during top-off to prevent the inhalation of chemical vapor. For chemical cargos that require eye protection, either a full face mask respirator, or a half face mask respirator with chemical goggles should be worn. The Safe Work Practice may also require the use of chemical protective clothing if the chemical is irritating to the skin.

SAFE WORK PRACTICE

Operation: Tank Entry For Internal Inspection, Chemical Tankership

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
1 Wash and ventilate the tank to be entered for inspection.	1 Cargo vapor vented to the air at deck level during ventilation.	1 Advise Crewman to stand upwind of the gas stream containing cargo vapor during tank ventilation.
2 Isolate the tank to be entered from the cargo transfer lines, and from all other tanks that may contain a non-gas free atmosphere.	2 Discharge of chemical liquid, vapor or gas into the tank while men are inside.	2a The Officer in Charge of the tank entry operation must ensure that the valves are closed on all lines entering the tank. 2b To prevent accidental opening, valves on all lines entering the tank should be lashed *closed and tagged*. 2c If a valve is not available to isolate the tank from a cargo line or a line to another tank, then a blank must be inserted into the line to seal it from the tank.
3 Obtain and fill out an Entry Permit Form. All questions on the Form must be answered. All persons involved in the tank entry operation should read and sign the Entry Permit.	3 Cargo tank entry can involve several potential hazards, including, o insufficient oxygen, o flammable gas atmosphere, o inhalation of toxic vapor, o skin contact with chemical residue, o overhead obstacles.	3 The Officer in Charge of the tank entry is responsible for the safety of the operation.
4 If the last cargo carried in the tank was a toxic chemical, record the values of TLV, STEL and enter them on the Permit.	4 Exposure to potentially hazardous chemical.	4 The TLV value is used as the upper limit of gas or vapor concentration permitted for men to enter the tank.

SAFE WORK PRACTICE

Operation: Tank Entry For Internal Inspection, Chemical Tankership

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
5 Test and calibrate the oxygen and combustible gas instruments that will be used to test the gas atmosphere inside the tank.	5 None.	5a Check that the batteries are charged. Replace if necessary. 5b Verify that the oxygen meter reads 21% in fresh air. Breath into the sensor and check that the level falls below 19.5%. 5c Verify that the combustible gas meter reads Ø% LEL in fresh air. Check the calibration at a known concentration.
6 The Officer in Charge must test for oxygen and flammable vapors at several levels in the tank. The values measured must be recorded on the Entry Permit.	6a Insufficient oxygen in the tank for breathing. 6b The gas concentration is the tank may exceed the lower flammable limit.	6a If the Officer in Charge must enter the tank to make these measurements, he must wear a Self Contained Breathing Apparatus (SCBA). 6b The oxygen level in the tank must exceed 19.5% for man entry to be permitted without an SCBA. 6c The combustible gas concentration must be less than 1Ø% LEL for man entry to be permitted.
7 If the last cargo carried in the tank was a Subchapter O chemical, and is potentially toxic by vapor inhalation, the Officer in Charge must test for toxic vapor concentration using a toxic gas detector tube (or equivalent method) for that chemical. The value(s) of concentration measured must be recorded on the Entry Permit.	7 Inhalation of toxic chemical gas or vapor.	7a If the Officer in Charge must enter the tank to make this measurement, he must wear an SCBA. 7b The vapor concentration must be less than the TLV value for men to enter the tank without an SCBA.

SAFE WORK PRACTICE

Operation: Tank Entry For Internal Inspection, Chemical Tankership

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
8 The Tank should be reventilated, and rewashed if needed, if the results of the tank gas atmosphere measurements, showed, (1) less than 19.5% oxygen, (2) combustible gas concentration greater than 10% LEL, or (3) a toxic gas concentration greater than the TLV.	8a Oxygen insufficiency, 8b Flammable gas atmosphere, 8c Inhalation of toxic gas or vapor.	8a If these three conditions are not satisfied, the tank entry must be undertaken only in case of an emergency. 8b In an emergency the tank entry must be under the supervision of the Master, and the men entering the tank must wear SCBAs and other protective equipment as directed by the Master.
9 Station a person at the tank hatch with emergency response equipment, including an SCBA, a life line, and a radio for summoning additional help.	9 Conditions that require an emergency rescue.	9 This person must remain at the hatch and be alert to signals from the men in the tank at all times.
10 If manual tank cleaning will be performed, following the inspection, to remove chemical residue, the tank must be ventilated while crewmen are inside the tank.	10 Vapor regeneration from chemical residue remaining in the tank after washing.	10 The Officer in Charge should determine that crewmen entering the tank have the proper protective clothing for the job of manual cleaning. This may include goggles, gloves, boots, slicker suit, as directed by the Office in Charge.
11 Give all persons entering the tank instructions for safely entering and working in the tank.	11 Accidental injury.	11 Establish a means of communication between the person at the tank hatch, and the men entering the tank.
12 After the Entry Permit has been completed, the Officer in Charge will direct the crewmen to enter the tank to perform the inspection or cleaning operation.	12 None.	12 The Officer in Charge will supervise the operations performed while crewmen are inside the tank.

SAFE WORK PRACTICE

Operation: Tank Entry For Internal Inspection, Chemical Tankership

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
13 On completion of the operation, the instrumentation and protective equipment used should be returned to the proper storage location.	13 Skin contact with chemical residue on gloves, goggles, protective clothing.	13a Wash and dry any protective equipment that was contaminated by chemical residue. 13b Check that the instrumentation used is still in good operating condition. Provide maintenance and repair as needed.

CONFINED SPACE ENTRY PERMIT

PERMIT NO. 00001

FOR ENTRY INTO: CARGO TANKS, BALLAST TANKS, COFFERDAMS, DOUBLE BOTTOMS, FUEL OIL TANKS, WATER TANKS, LUBE OIL TANKS, AND OTHER NORMALLY CLOSED SPACES NOT INTENDED FOR CONTINUOUS EMPLOYEE OCCUPANCY.

VESSEL -

DATE -

TIME OF PERMIT -

EXPIRATION TIME (MAX. 24 HRS.) -

CONFINED SPACE TO BE ENTERED -

DESCRIPTION OF WORK TO BE PERFORMED -

HAZARDS EXPECTED -

---TOXIC MATERIALS

---FLAMMABLE MATERIALS

---CORROSIVE MATERIALS

---RESIDUAL LIQUIDS

---OXYGEN DEFICIENCY

---OTHERS (SPECIFY)

	ALL QUESTIONS MUST BE ANSWERED	YES	NO	N/A
1.	HAVE VALVES ON PIPING TO THE SPACE BEING WORKED BEEN BLANKED OR CLOSED AND LASHED TO PREVENT ACCIDENTAL OPENING?			
2.	HAVE APPROPRIATE SIGNS BEEN POSTED OR TAGS ATTACHED TO THE APPROPRIATE VALVES?			
3.	HAS THE SPACE BEEN VENTILATED?			
4.	HAS THE SPACE ATMOSPHERE BEEN GAS TESTED AND FOUND SAFE FOR ENTRY AND SAFE FOR WORK TO BE DONE?			
5.	HAS FORCED VENTILATION BEEN PROVIDED FOR USE DURING THE JOB?			
6.	HAS THE WORKER BEEN FITTED WITH A SAFETY HARNESS OR SAFETY LINE?			
7.	DOES THE WORKER HAVE THE PROPER TOOLS FOR THE JOB?			
8.	HAS A MAN BEEN ASSIGNED TO WATCH THE WORKER AND HAS HE BEEN TOLD WHAT HE SHOULD DO IF THE WORKER GETS INTO TROUBLE?			
9.	IS THE PROPER RESCUE AND PERSONAL PROTECTION EQUIPMENT AVAILABLE AT THE TANK TOP?			
10.	HAS ADEQUATE ILLUMINATION BEEN PROVIDED?			
11.	HAVE THE MEN INVOLVED IN THIS JOB BEEN INFORMED OF THE HAZARDS THAT MAY BE ENCOUNTERED?			
12.	HAVE THE MEN INVOLVED IN THIS JOB BEEN GIVEN INSTRUCTIONS REGARDING THE SAFE AND EFFICIENT METHOD OF DOING THE WORK?			
13.	HAVE THE MEN INVOLVED IN THIS JOB BEEN TRAINED AND TESTED ON THE USE OF ANY NECESSARY PROTECTIVE EQUIPMENT?			
14.				

RESULTS OF GAS TESTING

CHEMICALS PREVIOUSLY IN THE SPACE	ACGIH TLV-TWA (PPM)	ACGIH TLV-STEL (PPM)	IDLH (PPM)	USCG SUBCHAPTER (O OR D)
1.				
2.				
3.				
4.				
5.				
6.				
7.				

OXYGEN CONCENTRATION -------% MEASUREMENT METHOD ------------

MEASUREMENT LOCATION ------------------------------

COMBUSTIBLE GAS TEST -------%LEL MEASUREMENT METHOD ------------

MEASUREMENT LOCATION ------------------------------

CALIBRATION GAS ------------------------------

TOXIC CONCENTRATIONS MEASURED:

CHEMICAL MEASURED	CONCENTRATION (PPM)	MEASUREMENT LOCATION	MEASUREMENT METHOD
1.			
2.			
3.			
4.			
5.			
6.			
7.			

CONDITIONS FOR VALIDITY OF PERMIT

REQUIRED PERIODIC OR CONTINUOUS MONITORING -

VENTILATION REQUIREMENT -

PROTECTIVE EQUIPMENT

--HARD HAT --CHEMICAL GOGGLES --HEARING PROTECTION --GLOVES

--CHEMICAL RESISTANT CLOTHING --BREATHING APPARATUS

--SAFETY HARNESS --SAFETY LINE --GAS TESTER

--FIRE EXTINGUISHER --FLASHLIGHT --OTHER (SPECIFY)

SPECIAL INSTRUCTIONS -

I HAVE INSPECTED EACH REQUIREMENT ON THIS PERMIT AND STATE THAT THIS WORK CAN BE DONE SAFELY AND IN COMPLIANCE WITH THE RULES OF THE U. S. COAST GUARD (46 CFR PARTS 30-40 AND 150-154), COMPANY POLICY, AND THOSE OF ANY APPLICABLE LOCAL AUTHORITY.

SIGNATURE OF THE OFFICER IN CHARGE OF THIS WORK:

I HAVE READ THE ABOVE PERMIT SIGNED BY THE OFFICER IN CHARGE. (BY SIGNING THIS FORM THE WORKER INDICATES THAT HE HAS READ AND UNDERSTANDS THE ABOVE PERMIT AND WILL ABIDE BY ITS CONDITIONS)

SIGNATURE OF WORKER -------------------------- TIME IN- TIME OUT-	SIGNATURE OF WORKER -------------------------- TIME IN- TIME OUT-
-SIGNATURE OF WORKER -------------------------- TIME IN- TIME OUT-	-SIGNATURE OF WORKER -------------------------- TIME IN- TIME OUT-
-SIGNATURE OF WORKER -------------------------- TIME IN- TIME OUT-	-SIGNATURE OF WORKER -------------------------- TIME IN- TIME OUT-

LOG OF PERIODIC OR CONTINUOUS MONITORING

VESSEL ____________________ DATE ______________

ENTRY PERMIT NUMBER ____________________

CONFINED SPACE TO BE ENTERED -

TIME	CHEMICAL MEASURED	CONCENTRATION (PPM)	MEASUREMENT LOCATION	MEASUREMENT METHOD	INITIALS

OFFICER IN CHARGE ____________________

NAMES OF PERSONS WHOSE INITIALS APPEAR ON THIS FORM

____

____

____

SAFE WORK PRACTICE

Operation: Open Tank Top-Off, Tankership Loading

	JOB ACTIVITY		POTENTIAL HAZARDS		SAFETY CONSIDERATIONS
1a	If the cargo being loaded is a Subchapter O chemical, that is potentially toxic by vapor inhalation, put on an air purifying respirator.	1	Chemical vapor is vented from open ullage hatches during open loading. Inhalation of chemical vapor may cause irritation to the nose, mouth and lungs, and it may cause adverse health effects.	1a	The officer on watch should verify that the air purification cartridge is the correct one for the chemical being loaded.
1b	If the cargo being loaded is not a Subchapter O chemical, and is not potentially toxic by vapor inhalation, a respirator is not required. But you should always avoid contact with chemical liquids and vapors during loading.			1b	Test for air leakage past the facepiece. Adjust the straps to minimize leakage. If you smell a chemical odor in the respirator, replace the cartridges.
2	If the chemical vapor is irritating to the eyes, or if it enters the body through the skin, inspect and put on chemical goggles or wear a full facepiece respirator.	2	Chemical vapor contact with the eyes may cause irritation or adverse health effects.	2	Clean the goggles or the respirator facepiece to insure clear vision.
3	If the cargo vapor is irritating to the skin, or if it enters the body through the skin, put on a chemical protective suit.	3	Chemical vapor contact with the skin may cause irritation or adverse health effects.	3	Clothing should cover the head, neck, arms and body.
4	Inspect and put on impervious gloves if the tank gauging operation requires you to handle a gauging rod or tape that has liquid chemical residue on it.	4	Liquid chemical contact with the hands and arms may cause irritation or adverse health effects.	4a	Inspect the gloves for cracks or punctures. Replace if necessary.
				4b	Rinse the chemical residue from the gloves before you remove the gloves from your hands.
5	Open the ullage hatch cover and remove the flame screen to gauge the cargo tank.	5	Exposure to chemical vapor.	5	Open the ullage hatch slowly to relieve any pressure built up in the tank.

SAFE WORK PRACTICE

Operation: Open Tank Top-Off, Tankership Loading

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
6 Gauge the tank visually or manually using a tape or a gauging rod. Record the ullage reading in your notebook.	6 Inhalation of chemical vapor, and skin contact with chemical liquid.	6 Stand cross wind or upwind of the open ullage hatch if possible. Allow the wind to carry the vapors away from the ullage hatch area.
7 Replace the flame screen after each time that the tank is gauged.	7 Accidental ignition of cargo tank vapors by a flame or a spark.	7 The flame screen must be left in place at all times to prevent a flame or spark from igniting the vapors in the cargo tank.
8 Inform the dockman when the loading has about 3Ø minutes to go.	8 Overfilling the tank, causing a cargo spill onto the deck.	8 Advise the dockman to remain in radio or voice contact.
9 Standby and gauge the liquid level continuously for the last 1Ø minutes of loading. Alert the dockman to standby the dock shutoff valve.	9a Overfilling the tank, causing a cargo spill onto the deck. 9b Inhalation of chemical vapors.	9 Have the dockman reduce the loading rate during top-off if necessary to avoid overfilling the tank.
1Ø Have the dockman stop the pump and shut the dock shutoff valve when the liquid level has reached the final ullage.	1Ø Overfilling the tank, causing a cargo spill onto the deck.	1Ø Watch the cargo tank level to confirm that the level is not increasing after shutdown.
11a Replace the flame screen. 11b Stand by the tank valve and advise the dockman that the vessel is ready to purge the loading line with nitrogen.	11a Ignition of cargo tank vapors. 11b Overfilling the tank, causing a cargo spill onto the deck.	11 Be sure that the nitrogen purge does not cause the tank to overflow. Partially close the tank valve and ask the dockman to reduce the flowrate of nitrogen ,if necessary.

SAFE WORK PRACTICE

Operation: Open Tank Top-Off, Tankership Loading

JOB ACTIVITY	POTENTIAL HAZARDS	SAFETY CONSIDERATIONS
12 When purging is completed, close the tank valve and the valve on the loading manifold.	12 Contamination of cargo.	12 Closing both the tank valve and the manifold valve prevents accidental contamination of the cargo in the tank.
13 The officer on watch should confirm the loading stop time with the dockman, and record the time in the ships logbook.	13 None.	13 None.
14 Replace the hatch cover on the tank after the cargo surveyor has measured the ullage. Tighten down the latches on the ullage hatch.	14 Contamination of cargo.	14 All cargo tank access holes must be closed and sealed during sailing.
15 Inspect, clean and return all of the protective equipment worn during loading to its proper storage location.	15 Contamination of protective equipment with chemical residue.	15a Wash, disinfect, dry and store the air purifying respirator. Dispose of used cartridges. 15b Wash and dry gloves, if used. 15c Wash and dry goggles, if used. 15d Return protective clothing to its locker. Decontaminate the clothing if necessary.

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